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## THE BASIS OF RESEARCH

IN the address on the significance of information in present-day industrial society which Prof. T. U. Matthew delivered to the Aslib Conference at the Hayes, Swanwick, last September, he rightly stressed the value of personal contact and initiative, although his theme was the extension and specialization of information services. This factor is often overlooked, and while Prof. Matthew suggested that the information function should now be formally recognized as a new function of management, and that the effective use of existing information depends largely on the extent to which management is 'information minded', he quite as explicitly recognized the vital importance of the initiative, enthusiasm and personality of the information officer or librarian himself. There was no suggestion that we can solve the problem of securing the effective utilization of existing knowledge by relying purely on mechanical means, such as adequately equipped libraries and information services, efficient organization or the latest and most elaborate devices for recording, filing and finding information.

To a large extent this view was reflected in the subsequent discussion; but one remark made by Prof. Matthew, and the discussion centring on it, suggest that the limitations of mechanization are still far from being fully understood; we are apparently not without danger of attempting to set up elaborate organization or equipment to do what will always be done more effectively by personal contact, and the cross-fertilization of minds which results therefrom. New information, said Prof. Matthew, is accumulating in scientific literature at a rate much faster than can be used effectively. That, of course, has always been true and is likely to remain so—no system of coding and indexing chemical compounds is likely to result in more than a mere fraction of the vast number of organic chemical compounds becoming more than laboratory chemicals. It is not surprising that the chlorinated diphenylethane now known as DDT should have remained a laboratory curiosity from its synthesis in 1874 until its value as an insecticide was recognized in 1939 as a result of a systematic search for moth-repellents. What is surprising is that Prof. Matthew and those who questioned him on the point should be so disturbed at a position which has many parallels. Scores of chemical substances have been prepared, described and recorded in the literature, and remained of a purely scientific interest until some technical development made urgent, for example, the discovery of products for use in accelerating the vulcanization of rubber, in preventing the oxidation and deterioration of rubber, fats and oils, foodstuffs, textiles and other materials, in preventing the icing of aeroplane wings or the freezing of the cooling systems of internal combustion engines, for the control of some pest or the treatment of some disease in animals or human beings. Once the need is recognized and the technologist can begin to formulate the requirements of the product he desires, it is often a simple matter to work by analogy through a series

of compounds until one is found which will provide at any rate a temporary solution.

Often, it is true, that is the starting point for extensive applied research, and even for more fundamental work; but it is well to remember that necessity is still the mother of invention. The limits of information services must be recognized, as indeed Prof. Matthew emphasized. No information service can supply the answer until the appropriate and specific question is put to it: it is no part of the process of invention or creation, though information services are an indispensable tool of the inventor and an invaluable aid to the creative worker.

In stressing, therefore, the contribution which efficient and adequate library and information services can render to technical and economic development, care should be taken not to claim too much. It is equally important to view the relations between science and technology in a proper perspective. Technology and applied science are not necessarily synonymous terms: not all technology has grown out of science; some science has grown out of technology. Engineering, for example, is sometimes described as applied physics, and it is true that to a large extent physics provides the theoretical basis for engineering. Nevertheless, from the earliest times down to the present, the technology has often come first, and only afterwards has physics supplied the explanation or theoretical basis. Frequently physical advance has depended on engineering science supplying the instruments and equipment for its investigations, and sometimes also the fundamental knowledge has been acquired in the course of what might be described as technological studies or research.

Indispensable as may be the help of the librarian or information officer to the research worker, the technologist or the industrial manager and administrator, mere mechanical efficiency and comprehensiveness must not be our objective. As Prof. E. Bright Wilson, jun., remarks in a recent book, "An Introduction to Scientific Research", wise selection rather than all-inclusiveness is the key to library work. Intelligent individuality and enthusiasm are the right counter to the cramping or isolating tendency of the growing mass of recorded scientific and technical information, and this applies to the user of such information as well as to the librarian.

For that reason alone, no improvements in abstracting services, indexing practices or other mechanical means for the dissemination of information and co-operation in information services will ever eliminate the need for contact between individual scientists and technologists themselves. It is probable, indeed, that even informal contacts, particularly where research is concerned, do in practice far more than is commonly appreciated to bridge the gaps in existing coverage of scientific and technical periodicals by abstracting services, and that in consequence the omissions to which Dr. S. C. Bradford directed attention twenty years ago are in any event not sufficiently serious to justify the expenditure of effort and resources which would be required to give complete cover. However that may be, the British Commonwealth Scientific Conference in Australia last year fully recognized the importance of personal contacts between scientists through visits to countries of the Commonwealth. Such visits were rightly regarded as fundamental to the success of Commonwealth collaboration in science, and the Conference attached the greatest importance to generous government provision being made to facilitate such visits.

Although the Conference was concerned mainly with the exchange of visits within the Commonwealth, it was manifestly equally aware of the value of the interchange of visits with scientists of other countries also. Free movement of scientific men across national frontiers and the reduction of visa and passport formalities and other restrictions to the minimum consistent with national security are a first condition of scientific and technical advance, though admittedly the situation to-day is one in which a balance has to be struck in any one country between opposing considerations. That balance should, however, be struck with a full appreciation of the price that has to be paid, and should take full account of changing economic and other conditions which may rapidly upset the appropriateness of the balance struck at any particular time.

If due care is taken in this respect and decisions are manifestly seen to be reasonable and not arbitrary or archaic by those directly affected, much less harm may be done to the interchange of thought and of information upon which the advance of science and technology depends. It is the former, indeed, that is vital, for progress depends above all on ideas. The danger in restricting the flow of information lies mainly in the risk that the creative mind may be deprived at the critical moment of some piece of information that might supply the missing clue to a new synthesis or invention.

There is, of course, the danger that the atmosphere of secrecy or restriction always tends to depress or hinder creative activity. Such an atmosphere can be fatal to creative processes of any kind, and although Mr. Brewster Ghiselin compiled his anthology "The Creative Process"* mainly with the view of assisting creative workers themselves to gain some insight into the factors or conditions which determine the efficiency or fruitfulness of their minds in creating, and thus enable them consciously to increase the efficiency of developed and active intelligence, it has a clear message for all those who are concerned with the control or direction of creative workers and the conditions under which they work.

Mr. Ghiselin does not distinguish clearly between creation and invention; but the anthology of writings collected in this symposium by some two score men and women who have paused to consider and describe the characteristics of their own creative processes cannot fail to help the creative worker who knows little of this literature or where to find it. The scientist or technologist will note some surprising omissions—Helmholtz and Rutherford, for example, and Nicolle's "Biologie de l'Invention" and Graham Wallas's "Art

* The Creative Process: a Symposium. Edited by Brewster Ghiselin. Pp. xii+259. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 6.50 dollars.

of Thought" are not quoted—and may find most interest in Poincaré's essay on mathematical creation, from "The Foundations of Science"; Einstein's letter to Jacques Hadamard, taken from "The Psychology of Invention in the Mathematical Field"; Herbert Spencer's conversation with George Eliot, taken from his autobiography; and R. W. Gerard's paper on the biological basis of imagination. The selection, from the point of view of the scientific worker, seems a little unbalanced, though allusions in Mr. Ghiselin's introduction and in Mr. Gerard's paper restore the balance slightly; but there is much more than Mr. Ghiselin's introduction to the volume to give unity to the book. There are passages in some of the accounts of how composers and poets work, such as in Morton Prince's remarks on subconscious intelligence underlying dreams, which recall and repair some of the more obvious omissions—a well-known passage in Nicolle's "Biologie de l'Invention", for example—and the scientist or technologist who reads these varied accounts will find much that bears closely on his own inventive efforts.

It is not suggested that the evidence here presented of the way, in varied fields, in which creative minds work is likely to help the reader, whether scientist or not, to manage his own creative processes, assuming he is capable of such work. In fact, there is clear evidence that at a certain stage too much conscious control of thought may kill the new idea which the unconscious mind is developing. Mr. Morton Prince's account of the writing of a poem as a subconscious process, following a dream and vision which had succeeded several days of attempts to write verse and of reading much poetry, recalls both Sir J. J. Thomson's remark that new ideas about a subject come when one is not thinking about it, though one must have thought about it a good deal before, and the way in which sudden insight or the solution of a problem sometimes seems to occur at the moment of waking.

This point has frequently been stressed in discussions of the subject, notably by C. Nicolle in "Biologie de l'Invention", by W. B. Cannon in "The Way of an Investigator" and especially by J. Livingston Lowes in his study of the working of Coleridge's imagination. This last, "The Road to Xanadu", is the only one mentioned by Mr. Ghiselin, and although he emphasizes the parallel between Lowes's study and the biological study of Dr. Gerard, so far as the scientific man is concerned this book can be usefully supplemented by others such as those of Poincaré and Hadamard, or by following up the clues suggested in some of the chapters of Prof. W. I. B. Beveridge's "The Art of Scientific Investigation".

What emerges most clearly from this anthology is that while we can do little positively to encourage the creative process, the moment of intuition or illumination, or the act of invention, it is fatally easy to discourage or repress such moments of vision or creation. Every care should be taken to avoid the disturbances that are fatal to such activity, though it is not suggested that it is practicable or desirable for the creative worker, be he inventor or scientist or artist, to be immured in an 'ivory tower'. Indeed, to do so would often remove the vital stimulus and the intellectual stress and tension that precede creation.

Few have brought out the position better than Helmholtz, who distinguished three stages in the act of invention or creation: first, a period of preparation in which the problem is examined; next, a period of incubation, in which often the mind is not consciously occupied with the problem; and third, the moment of illumination, which is usually spontaneous and unpredictable. To these, Wallas and Poincaré add a fourth stage, that of verification when the subject is worked out in its entirety. A very similar analysis was given by Sir Henry Cohen in his Harveian Lecture, "Harvey and the Scientific Method", in March 1950, and clearly the first and last stages call for conscious hard work, and for a determined effort animated by a passion for the subject. At the first stage also, stimulus—not, however, distraction of the type already suggested—can be fruitful.

It is in the full sense of all that is involved in preparation of this type that Pasteur's adage applies, "Chance only visits the prepared mind"; or, in the words of Nicolle, "Chance favours only those who know how to court her". This granted, it is of the second and third stages that we need to take care and in the sense indicated by Helmholtz's well-known remark: "Happy ideas come unexpectedly without effort, like an inspiration. So far as I was concerned, they have never come to me when my mind was fatigued, or when I was at my working table. . . . They came particularly readily during the slow ascent of wooded hills on a sunny day".

Sir Michael Sadler put it similarly: "The ideas come—not when I am under great strain or threadbare with overwork, but after a period of rest (including physical exercise and distraction of thought) following on a period of very hard work and of grappling with real unsought difficulties . . . the ideas come to me unsought and I find them in my mind exactly as I might find a half-crown that somebody had put into my pocket while my coat was hanging up in my absence". To the testimony of Helmholtz and Sadler the attention of the administrator might well be directed. He can do little to assist the mobilization of the contents of memory, which C. J. Renier defined as the essence of imagination, still less to assist the perception of the value of qualities which in Shelley's view was the essence of imagination. Administrative action can scarcely protect the artist or the investigator from the anxieties and strains to which their fellow men are exposed, and indeed from such tensions may result the stimulus to some great moment of discovery, creation or invention. There are, however, innumerable smaller matters that can seriously prejudice such moments by the irritation and distraction they cause, and with these the administration is closely concerned. Restrictions on the interchange of scientific or technical information may, for example, well deprive the man of science of some invaluable fact or clue which in the period of incubation his subconscious mind may transmute into some new idea or insight. Even if harm is not done in this way, he may be deprived of the invaluable stimulus

of personal contact, or the irritation engendered by unnecessary restrictions may cause a frame of mind utterly opposed to that tranquillity in which Helmholtz found new ideas came most readily.

That is the real reason why restrictions on scientific intercourse and the exchange of information should be such as manifestly commend themselves to scientific men as reasonable, and are accordingly accepted without a feeling of irritation or frustration. We do not yet know how the imagination works, but we know at least some of the conditions which are inimical to it. Mr. Gerard's paper does not indeed take us a great way further than Lawes, with whose brilliant analysis of the working of Coleridge's mind, in effect, he starts. Creative imagination, to Mr. Gerard, is an action of mind that produces a new idea or insight, and while he admits that a satisfactory interpretation of imaginative phenomena in terms of neural mechanisms is a matter for the future, his discussion of the psychology, anatomy, pathology and physiology of imagination in essence largely confirms the conclusions reached by others who have attempted to record their experience of the creative process. He points clearly to the danger of reason stifling imagination; and the challenge to education which the teaching of rigour without stifling imagination still presents is set forth unmistakably.

Nor are the emotional factors overlooked. Quoting Pavlov's insistence on the need for passion, in the conscious work preceding that of imagination, Gerard remarks that the unconscious work goes on over problems that are important to the waking mind only when the mind's possessor worries and cares passionately about them. This, it is true, relates to the conscious work recognized by Poincaré and Helmholtz as preceding the unconscious work of imagination—to the mastering of accumulated knowledge, gathering new facts, observing and experimenting, developing technique and skill, selection and discrimination, which are all more or less conscious and voluntary activities, as Ghiselin points out.

To the second period of conscious work recognized by Poincaré as preceding the unconscious work of imagination Gerard attributes, however, a second emotional factor—that of courage. Without courage the unfamiliar will not be faced, or that which is different or new espoused, no matter how well prepared the climate of opinion may be. It is at least arguable that certain anti-scientific trends to-day have enhanced the importance of this emotional factor. At the best, invention is liable to be precluded by distrust of deviation. Ghiselin's anthology will not give much fresh guidance as to the working of the creative mind, or how the process of invention or creation occurs. None the less, it shows clearly enough that the mind in creation and in preparation for creation usually requires some management; and to the creative worker and to the administrator alike it indicates both conditions which are favourable to the creative process and also some of the factors, disturbingly active to-day, which discourage creative and imaginative work in science, art and technology, and which cause the waste and frustration to which Mr. Ghiselin directs attention.

# ALBERT HEIM (1849–1937)

**Albert Heim**

Leben und Forschung. By Marie Brockmann-Jerosch and Arnold and Helene Heim. Pp. 268+15 pl. (Basel: Wepf and Co., 1952.) 17.80 Swiss francs.

SCOTS geologists a few years ago were commemorating the one hundred and fiftieth anniversary of the death of James Hutton (1726–97). Now Swiss geologists have issued a volume to mark the centenary of the birth of Albert Heim (1849–1937). Towards the close of the fifty-odd years separating the two events, Arnold Escher von der Linth reported on wonders of large-scale tectonics, which he had recognized in the Glarus Canton and neighbouring regions of the Alps. It was in relation to these wonders that Heim achieved unique international fame. Two of his publications are outstanding, his "Mechanismus der Gebirgsbildung" (1878) and his "Geologie der Schweiz" (1919–22). Heim was fortunate at both ends of his career, for inheritance from Arnold Escher allowed of a flying start, while support received from pupils, especially his son Arnold Heim, was of great service in later years. In addition, he was a very remarkable man.

The book here under review considers this remarkable man from a number of different aspects: for example, his family life, tectonic and glacial research, drawings and relief models, academic activities, application of geology to welfare and safety, joy in mountains, breeding of Newfoundland dogs, and finally ethics, including total abstinence.

The child Heim promised well; but it seems that he would have been lost to science except for a strange accident. He came to be afflicted with recurrent headaches, so much so that he had to be removed from school and set to work on a farm. Here, fortunately, in 1865, he was overrun by a shy-horse (*von einem scheu gewordenen Pferd*) with its cart in tow. It broke him in seven places; but when eventually he got out of bed, though he had to supplement a shortened leg with a thick sole to his boot, his head was clear and he was able to resume his studies.

Many anecdotes enliven this book. They are written with becoming piety, but not without humour. There is, for example, the story of a trick Baltzer played during the 1907 celebration of the centenary of the London Geological Society. Heim, on return from Oxford, where he had received an honorary doctorate, found an invitation from a lord (*eines Lords*) to a reception in evening dress. Heim, with a strong prejudice against dress clothes, declined with thanks. Then arrived a package with a letter purporting to come from the lord, "who regarded it as an honour to offer the great scholar Heim evening clothes for his reception". Baltzer and his conspirators were repaid with no little anxiety during the ensuing ceremony lest Heim should elude them and publicly thank the lord for his *Aufmerksamkeit*.

In 1920 the trickster was Dame Nature herself. A fissure opened on the mountain face above the village of Linthal, threatening a landslip of 100,000 cubic metres. The cleft was kept under observation and increased daily by 1–27 mm. Eventually Heim delivered a speech to the villagers, the draft of which occupied some fifty pages. He besought them to evacuate; but their hesitating partial concurrence drove him to despair and brought him sleepless

nights. Then, though blocks continued to thunder into the valley, the mass as a whole came to a standstill. It is sad to read that their escape led the inhabitants to ridicule geologists in general, and Heim in particular. As a rule, however, Heim's advice on practical matters won great respect; and among the people at large he was better known for his views on water, tunnels, avalanches and landslips than for his theories on mountains and glaciers.

Heim was not only a first-class field geologist and an excellent writer, but also an artist, who found expression in drawings and relief models. Probably geologists have learned more from his pictures and sections than from those of any other, except perhaps W. H. Holmes, of Grand Canyon fame, and W. M. Davis, of altogether different style. It is interesting, too, that it was passion for relief modelling that introduced Heim to geology.

When not quite ten years old, after his first mountain trip with his father, Heim began to reproduce what he had seen by pasting together little stones and capping them with sugar in place of snow. When twelve he saw for the first time a genuine relief, and realized what he had been striving to attain. Then he found a 1 : 50,000 map of the Glarus Canton exposed in a shop window; and a year of window-gazing and perpetual intercession persuaded his parents to spend the 3 francs necessary for its purchase. Modelling from this map in potters' clay brought only short-lived joy, for Heim soon realized that the map was incorrect. So in 1865 he got permission to wander for eight days among the Tödi mountains and make drawings of his own for guidance. Thus during the next year he was able to include a relief of the Tödi group, 1 : 25,000, among his drawings for the Canton school examination. Hearing of it, Escher, though a stranger, called at his father's house to see this exploit of a schoolboy; and, recognizing its worth with delight, invited its young author to attend his excursions. In these Heim came to realize that to produce a really correct model of a mountain one must learn its composition and development.

Heim with his own hand did much of the backward engraving on stone or copper required for reproduction of his illustrations, often setting up the original in front of him and proceeding without further help. He published his first panorama at about the same time as he exhibited his Tödi model. In after years when he took his students to the mountains, he would halt them and say: "Let us draw".

As might be expected, the book gives us the tale of Heim's conspicuous mistake, the Glarus double fold, and of his splendid recovery in 1902. Perhaps, however, the most welcome single feature is a full report of a speech Heim made on his eightieth birthday, when he led his last excursion to the Lochseitenkalk at the type locality of the Glarus overthrust. In it he explained that for the past few years he had been searching through half-published and unpublished records of Escher's observations, and had come to realize as never before the fullness of his master's appreciation of nappes in the make-up of the Helvetian Alps.

It is a small matter, but British geologists will be pleased to see reproduced Heim's portraits of Peach and Horne, the "Investigator Twins" as he happily called them. These portraits he sketched during a famous excursion to the North-West Highlands in 1912.

E. B. Bailey

# A HARMONY OF PROPORTIONS

## Symmetry

By Hermann Weyl. Pp. vii+168. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 24*s*. net.

THIS intriguing book represents what was, in effect, Prof. H. Weyl's farewell to the Institute for Advanced Studies in Princeton. It deserves to be read by anybody who not only desires some guidance through the subtleties of symmetry, but who also is willing to respond to the æsthetic bearing of the subject. This link is the essence of the author's contribution: it is fundamentally more important than the elegant proofs of transformations, translations and rotations which occur in abundance. For, after all, with a little trouble they can be found elsewhere, but the examples of symmetric ornament cannot. Perhaps it is admissible to remark that here we have a new—and most welcome—recruit to the very restricted literature of shape in relation to beauty (both natural and artificial) associated particularly with the names of Birkhoff, Speiser and (as editor) Whyte. On the periphery comes Wittkower and his treatise on humanist architecture. Thus, these pages cannot be read in isolation; whatever their exact origin may have been, their outlook is too synthetic and their implications for the whole of culture too wide. Symptomatic of the age, they are distinguished by their emphasis upon a topological habit of mind, and by a certain sturdy objectivity in showing that many of the delights of Nature are but straightforward examples of a minimal-energy economy, rather than instances culled from metaphysical speculations. In this way, Prof. Weyl does good service to science without introducing ontological arguments set in a plane of discourse for which they are often inappropriate. At the same time, there is an undercurrent of sympathetic understanding for the artist, whose works are necessarily unique, and incapable of inclusion in any algebra of classes.

The reader is confronted with four main divisions —bilateral symmetry; translatory, rotational and related symmetries; ornamental symmetry; and crystals. Appendixes deal with the highly specialized subjects of 'proper' and 'improper' rotations.

In his choice of historic examples of mathematical embellishment, the author excels. This is where the book is *sui generis*, good as the formal parts undoubtedly are. The Sumerians had a passion for strict bilateral devices; by contrast, Western tendencies were to loosen rigid symmetry. To the crystallographer there is something compelling in a design such as that of the Etruscan tomb of the Triclinium. Here we meet with a certain 'imperfection' (akin to 'real' crystals) which, judged by formal standards, makes the pose of the horsemen and the stance of the animals on the side-panels much more interesting than they would otherwise be.

Turning to architecture, Prof. Weyl mentions the great central church of S. Maria degli Angeli at Florence (by Brunelleschi) which is octagonal. As he remarks, pentagons and hexagons are rarer, though, as a matter of fact, they occur in designs in Serlio's fifth book of 1547. Apparently, deliberate structures seldom simulate the five-fold character, so frequent in the floral kingdom.

All this, and more, is to be found in this well-produced little volume. Occasionally we hear of encouraging signs that men of science and humanists

are not only trying to find common ground for studying natural and man-made forms by comparative methods, but are also succeeding. Here, indeed, is a book to help them. F. I. G. Rawlins

## ZOOLOGICAL LITERATURE OF 1950

### The Zoological Record

Vol. 87, being the Records of Zoological Literature relating chiefly to the Year 1950. Edited by G. Burder Stratton. Pp. vi+1507. (London: Zoological Society of London, 1953.)

THE serious student of zoology is greatly indebted to the Zoological Society of London for the production of the annual volumes of the "Zoological Record" in spite of continually increasing costs. It is difficult to imagine how any systematist could ever succeed in tracing the literature of his subject without this annual list of titles of zoological papers, published usually within thirty months or less of the end of the year to which any particular volume relates. The present volume, No. 87, deals principally with the literature of 1950 and comprises more than thirteen thousand references, classified into eighteen sections, and a final chapter giving a list of new generic and sub-generic names.

The activity in different branches of the subject is to some extent indicated by the number of titles in each section, ranging from Porifera, with only sixty-six titles, up to Insecta, which overwhelms all other sections with a total of 3,101 titles, almost a quarter of the whole volume. A glance through these sections reveals some rather unexpected figures, for under Aves one finds more than sixty new species and subspecies recorded, although the ordinary zoologist would have imagined that at least in this class very few new forms remain to be discovered.

Each section begins with a list of titles followed by a subject index briefly indicating the papers dealing with particular branches. Thus the subject index of Protozoa has sections on text-books, history, biography and obituary, bibliography, taxonomy, technique, structure, physiology, locomotion, sexuality, effects of environment and stimuli, effects of chemicals, development, evolution and genetics, ecology (including parasitism), economics and distribution (both geographical and geological) and, finally, a systematic index. The sections may be purchased separately from the Zoological Society of London (Regent's Park, London, N.W.8), except for the section "Insecta", which is obtainable only from the Commonwealth Institute of Entomology (41 Queen's Gate, London, S.W.7). It is rather surprising that, judging from the sales, more use is not being made of these sections of the "Zoological Record", for as a result of various donations they are supplied at a price far below the cost of production.

Zoologists are greatly indebted to the specialists responsible for the compilation of the various sections, and whose services are obtained more or less on a voluntary basis. One notable change occurs on the title page. The present volume is edited by Mr. G. Burder Stratton, librarian of the Zoological Society of London, whose name replaces Dr. A. Malcolm Smith, who has been editor of the "Record" since 1938 and to whom zoologists throughout the world owe a special debt of gratitude for his valuable services. Edward Hindle

## INDIA'S FOOD PROBLEMS

### Food and Population and Development of Food Industries in India

Pp. xv+357. (Mysore: Central Food Technological Research Institute, 1952.) 10s.

OF all the free nations of the world, few have more difficult food problems than the Union of India. The population is about 357 millions, an increase of some 40 millions over that of 1941; the area of sown land per head in 1951 was 0·6 acre and has long been shrinking, for in 1911 it was 0·9 acre. This shrinking area has to provide not only food but also cash crops, especially cotton and non-edible oil seeds. Some land is still unused, but it usually has some disability more or less difficult or costly to remove; there is still the possibility of more irrigation which would enable the land to carry two crops a year instead of one and also to give higher and more certain yields. But meanwhile the health services are improving: anti-malarial operations are saving great numbers of lives, and it has been estimated that, even if all the optimistic plans of 1951 could be carried through, the nation's food position in 1956 would be no better than it is to-day.

One of the most hopeful features in this difficult situation is the seriousness with which Indian agriculturists and food experts are dealing with it. The numerous problems involved were discussed in two impressive symposia held in May 1951 at the Central Food Technological Research Institute in Mysore, a remarkable organization under the direction of Dr. V. Subrahmanyan: both food production and food processing were dealt with. The papers are collected in this volume, and they give an admirable summary of the ideas and methods of the Indian experts and of the problems as they then stood.

The discussions ranged chiefly around the possibilities of increasing production of food grains, of increasing yields of all crops, improving methods of storage and preservation, reducing wastes and losses, and utilizing more widely foods at present confined to certain localities but capable of considerably higher output per acre than those at present grown. The main facts are already well documented; but they are set out here with great clarity and in handy form. If there is a certain amount of repetition, it is justified by the grim importance of the subject.

Serious complications arise in India from the circumstance that the choice of food is governed not simply by economic but also by social and religious factors: custom especially plays a large part. Great numbers of the population will eat only rice as their staple food, although cassava would give much higher yields per acre. Dr. Subrahmanyan has ingeniously made a 'synthetic rice' by moulding a mixture of tapioca and groundnuts into grains of the size and shape of rice grains; how far these will prove acceptable remains to be seen. Other possibilities discussed include the utilization as human food of various oil-seed residues, groundnut and others, at present fed to cattle or used as manure. The current grain shortage is about 10 per cent of the total consumption, but this is increasing yearly: Indian agricultural experts are making great efforts to narrow or even close the gap. The book gives an excellent description by the workers themselves of the way they are setting about their task. E. John Russell

## The Yearbook of the Universities of the Commonwealth, 1953

(Thirtieth Issue.) (Published for the Association of Universities of the British Commonwealth.) Pp. liv+1805. (London: G. Bell and Sons, Ltd., 1953.) 63*s*. net.

THE Commonwealth Universities' "Yearbook" has become firmly established as a 'hardy annual' and one the blooms of which grow bigger with each successive year. The edition for 1953 (the thirtieth) is larger than ever because the staffs and activities of the individual universities are increasing and because new institutions are continually being established. Thus the present edition contains new entries for three Indian universities (Baroda, Bihar and Visva-Bharati) and for one in Pakistan (Karachi); in Canada the Nova Scotia Technical College now has a full entry on becoming a member of the National Conference of Canadian Universities, and in the United Kingdom the entry for Southampton has been moved from the college to the university section.

In Appendix 1 of the "Yearbook" the usual account of the qualifications required for admission to a first-degree course in United Kingdom universities has been augmented with similar material for Canada, Australia and South Africa. The eight other appendixes have all been revised and in some cases increased, especially Nos. 2 and 3, dealing with United Kingdom postgraduate awards tenable at home and overseas, respectively. The introductory surveys that are to be found at the beginning of each national section have also been considerably revised and, in particular, those for Canada, India and Pakistan completely rewritten. The name index now runs to 151 pages, with a grand total of thirty thousand names.

The seventh quinquennial congress of the universities of the Commonwealth will be held in Cambridge later this year, and this volume should prove of inestimable value to the delegates as a reference work; but its usefulness will not be confined to the congress, for experience shows that this volume is a reference book which quickly shows honourable marks of constant use.

## Introduction to Metamathematics

By Prof. Stephen Cole Kleene. (Bibliotheca Mathematica, Vol. 1.) Pp. x+550. (Amsterdam: North-Holland Publishing Co.; Groningen: P. Noordhoff N.V., 1952.) 32.50 fl.

THERE will be a warm welcome for a book of this nature by one who is a distinguished member of the American mathematical fraternity. Outside the *Journal of Symbolic Logic*, which cannot be expected to be suitable for teaching purposes, it is hard to find an English text wholly fitted for university work in meta-mathematics. The advantage of the present volume is that it contains practically everything necessary (somewhat massive as it is) between the same two covers.

There are four main sections, namely, the problem of foundations, mathematical logic, recursive functions, and some additional topics in mathematical logic. Actually, the last is almost a supplement dealing with the predicate calculus and consistency proofs. It may not always be wholly advisable to follow the author's preference for starred and unstarred paragraphs: the same applies in general to an encounter with Gödel's two famous theorems before tackling the lemma establishing the primitive recursive character of certain predicates. But these are details. The main strength of the development followed by Prof. Kleene stands out at the end of Part 1, where he collates the essential ingredients of the 'full picture'. These are (*a*) the informal theory, (*b*) the object theory, and (*c*) the meta-theory, in which (*b*) is examined.

An adequate bibliography, a list of symbols and notations, and an index bring a most valuable compilation to a close. F. I. G. RAWLINS

## Chemistry in Action

By Prof. George M. Rawlins and Alden H. Struble. Second edition. Pp. viii+575. (Boston, Mass.: D. C. Heath and Co.; London: George G. Harrap and Co., Ltd., 1952.) 21*s*.

THIS book describes a one-year course in chemistry for American high-schools. The author's plan seems to be to make chemistry attractive by stressing fascinating applications of it to everyday affairs. The scope covers approximately the requirements of the British matriculation syllabus, with the addition of more than a hundred pages on hydrocarbon chemistry; this permits alluring discussions on such topics as textiles, food, penicillin, stain-removal and insecticides. The whole is built on a rather slight framework of theory. The book is replete with illustrations; most of the half-tone plates illustrate not fundamental principles but interesting and occasionally sensational applications of the science. Much information is given in the form of tables, and some by picture and caption only. There are many sets of questions and numerous reading references.

The worth of the book is its content of interesting up-to-date factual matter. Pleasing to look at and read, it would serve to acquaint a non-scientist with the role of chemistry in everyday life. There is too little of the grammar of science for the book to be used in Britain as an examination text, but, as a supplementary reader or as an aid to a teacher to brighten his lessons, it is worth consideration.

G. F.

## General Genetics

By Adrian M. Srb and Ray D. Owen. (A Series of Biology Texts.) Pp. x+561. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1952.) 5.50 dollars; 47*s*.

AS a text-book for courses in elementary general genetics, this book constitutes a welcome addition. There are features which make it valuable, though unfortunately the price is not one of these. First, there is novelty and variety in the choice of examples; second, the illustrations are particularly effective; third, the developments of the past ten years are amply dealt with; and fourth, there is a very salutary discussion of the principles involved at every step in the logical sequence of the chapters. This last quality ensures that the student will be well aware of the fields in which genetical theory is most promising and of those in which it is weaker. Among the criticisms which might be made, one is shared with all other previous text-books, namely, the inconsistent use of the words "gene", "allele" and "locus", though, of course, a good deal of the inconsistency is in the nature itself of the concepts. Another criticism is that the chapters on quantitative inheritance and on population genetics are rather slight. On the whole, this text-book is likely to be useful to those who have the task of teaching elementary genetics to students who have a varied background and not much of it at that.

G. PONTECORVO

# THE LIFE AND TIMES OF SIR RICHARD GREGORY, Bt., F.R.S., 1864–1952*

By Sir HAROLD HARTLEY, K.C.V.O., F.R.S.

IT was at our meeting last year at Belfast that for the first time for more than fifty years we missed the presence of our most constant member, whose friendships and devotion to science, and his keen mind and sense of humour had given him a unique position as a vitalizing and constructive force in the work of the British Association. It is most fitting that this Pedler Lecture, which was his way of commemorating the work of Sir Alexander Pedler as secretary of the British Science Guild, should be a tribute to the life and work of our old friend Richard Gregory himself.

His life-history is a record of successful endeavour that would have delighted the heart of Samuel Smiles as an example of what courage and grit and devotion to science can accomplish. It is a thrilling story of heredity, circumstance, education and opportunity. Gregory was proud of his ancestry, and in his study hung a photograph of the inscription to his grandfather, a shoemaker of Bideford :

"He was a consistent member of the
Wesleyan Society for 65 years,
And as a local preacher and Class Leader,
His Labours were blessed
To the Salvation of Many Souls."

John Gregory, his son, followed the same craft but also was one of Nature's poets. I found among Richard's papers this charming letter from H. G. Wells to the old man when Richard had sent him one of his father's slender books of verse in 1907.

"Dear Mr. Gregory,

"You will I hope forgive my writing to you to tell you how much I like and value your book of poems. Your son has just given it to me and I have been reading in its contents a constantly increasing delight and surprise. He had often told me you wrote verse but he had given me no idea of the simple, curiously straightforward graciousness of your songs. They come I think most appropriately with this spring time ; they have so much in common with the bright freshness of primrose and aubrietia and all the daffodils and narcissuses with which the garden is singing. I have been reminded of Blake and Herrick and of all that is most truly English as I read. R.A.G. is one of my earliest friends—I didn't expect at this date to find a quite new reason for liking and respecting him—in such a book as this.

"I am myself a sort of literary man though I've never risen to either verse or science. That must be my excuse for bothering you with these praises.

"Yours very sincerely,
"H. G. Wells."

Richard was born in 1864 in Bristol, where his father had moved from Bideford. When he was six he went to the Wesleyan Day School at Baptist Mills, where three hundred boys were taught in groups in one large schoolroom heated by a single fire-grate. In 1874 he entered the secondary school, now called Queen Elizabeth's Hospital, a boarding school with a uniform rather like Christ's Hospital, where his interest in science began. He left school early owing to his delicate health and began life like Faraday as a newspaper boy, and with his father more interested in poetry than shoe-making, it sometimes happened that his mother could buy no food until Richard returned with his weekly earnings. John Gregory must have had something in common with Blake and his idealism left its mark on Richard. One of his poems reveals his attitude towards wealth :

"My heaven is not paved with gold ;
For all that has been writ of it,
I would not have it if I could,
There's blood on every bit of it.

I would not harm my angel's feet
With such a hateful use of it ;
I loathe, I scorn the thought unsweet,
Because of man's abuse of it."

When Richard was fifteen he was apprenticed to a boot factory for five years to learn the trade of clicking, that is, cutting out the various shapes of leather that were to be the uppers of boots and shoes. He was unhappy in his work and spent all his spare time attending evening classes in the Bristol Trade and Mining School (now the Merchant Venturers' College) and reading in the St. Agnes Club Library.

John Gregory was one of a band of socialist reformers in Bristol actively engaged in establishing the socialist and labour movement. The group included Ben Tillett, Jim O'Grady, later Sir James and High Commissioner in the Commonwealth of Australia. Ramsay MacDonald joined them for a short time in 1884 when he came to Bristol to help with a boys' club. At that time he meant to become a science teacher, and when he was Prime Minister he said to Richard, "You chose the better part".

Richard and his father were great friends and in those early years he was closely associated with him in his social work. At evening meetings John would give an address on some labour problem or recite some of his poems and Richard would sing or give a talk on a scientific subject, often astronomy, in which he was even then keenly interested. John Gregory became a well-known figure in Bristol and in 1912 he was given an honorary degree by the University, an honour which Richard was to share with him thirteen years later.

When he was seventeen he won the Latin prize at the Trade School. Canon Wilson, a great educational reformer, was then headmaster of Clifton ; he was an admirer of the personality and poems of Richard's father and often came to see him. He encouraged Richard with his Latin, and knowing his wish to leave the factory and learn science, he offered him the vacant post of laboratory assistant at the College. Richard had to secure his release from his indenture and paid an indemnity of £5, which A. M. Worthington, the physics master, lent him, to be deducted from his first term's wages. One of his congenial duties at the College was the care of the fine eight-inch telescope.

* Alexander Pedler Lecture of the British Association, delivered in the Royal Institution, London, W.1, on May 28.

Here at last came the opportunity he had dreamt of during his years at the boot factory and he took full advantage of it, continuing his studies in science and mathematics to such good effect that three years later he gained a scholarship in the Science and Art Department examinations which enabled him to become a science teacher in training at the Royal College of Science, South Kensington. Huxley was then dean of the College, and a new world opened for Gregory. He gained first classes in astronomy and physics and two years later, in 1887, he became a science demonstrator in H.M. Dockyard at Portsmouth. His main interest was still astronomy, and in 1889 he returned to the Royal College of Science as computor to the Solar Physics Committee and assistant to Norman Lockyer.

At each stage of his life Gregory was fortunate in his friends. At South Kensington he and H. G. Wells were fellow students and they were close companions. Wells has described in "Love and Mr. Lewisham" and in his "Experiments in Autobiography" the aims and hopes and struggles of the students of the College at that time. Forty years later he wrote of Gregory: "He emerges in my memory as a bland and sturdy figure in the debating society, a little troubled then as ever about the letter 'r', friendly, hilarious, hard-up and working hard, one of the cheerful and often quite audible group which includes William Burton, the potter, and A. T. Simmons. We had no relatives to push us on, we had to do all our own pushing, and sometimes the pushing was very hard indeed.

"Gregory pushed his upward course by way of sunspot computation to the stars. He won the respect and confidence of Sir Norman Lockyer. But before his footing was well established there were some precarious times. I had not so much pushed my way up as out by starting the *Science School Journal* (which is now the *Phoenix*) and similar depravities and my times were even more precarious. We collaborated in a book on 'Physiography' (Gregory got the job for me) and earnt £10 each. Ten pounds were worth getting in those days. We lent each other money and returned it (though social observers declare that such returns never happen). We followed our destinies. All sorts of things happened to me but nothing ever changed the steadfast friendship and helpfulness of Gregory."

Gregory's work with Lockyer was of a routine nature, measuring the areas and positions of sunspots and faculæ in photographs taken during 1878–81 at Dehra Dun, Mauritius and Melbourne. He was also concerned in some unproductive work on the widened lines in sunspot spectra and he photographed the spectra of a number of elements. That was his only direct contact with research, and his name does not figure in any paper. But Lockyer's work on the orientation of temples in Greece and Egypt appealed to Gregory and was the start of his life-long interest in the relations of astronomy and religion.

Soon after he joined Lockyer's staff, Gregory's articles and reviews began to appear in *Nature*: in 1889 "On the Determination of Masses in Astronomy" and "The Planet Uranus"; in 1890 on "Comets of Short Period", "Lunar Photography" and "Electrical Storms on Pike's Peak". In the same year he became an Oxford University extension lecturer on astronomy and physics, and in 1892 he left the Royal College to become a free-lance lecturer and writer. Lockyer, however, had realized the quality and promise of his literary work and in 1893 made him assistant editor of *Nature*, which first brought him into touch with Macmillans, its publishers. So the opportunity came to Gregory to devote his life to securing recognition for science and scientists, and to ensuring that they were given the chance to make the contribution to progress on which he believed the future depended. He had come up the hard way and he did his best to awaken a realization of the readjustments in social and economic conditions that the new technical age was making imperative. Gregory used every means of reaching his objective: education, journalism, the British Association and the British Science Guild.

## Education

Gregory had had to fight so hard for his own education and had suffered so much from the lack of text-books that he saw here a great opportunity. His first book, "Elementary Physics and Astronomical Geography", was published in 1891. It was the first of many text-books that flowed from his ready pen or were inspired by his editorship. His own books were notable for their clear writing, systematic arrangement, for their recognition of the relation of theory and practical work, and for the lively interest they created in the practical applications of science. His second book was an elementary physiography, a description of the laws and wonders of Nature. After that came "Honours Physiography" with H. G. Wells in 1893, and in the same year "The Vault of Heaven", and next year "The Planet Earth". Meanwhile, he was getting experience as an Oxford University extension lecturer and in 1898 he became professor of astronomy at Queen's College. The same year saw the beginning of his long partnership with A. T. Simmons, with whom he started the *School World* (later incorporated in the *Journal of Education*) and the series of joint text-books, which they produced in new editions until Simmons's death in 1921.

In 1905 Gregory became scientific editor to Macmillans, a position he held until 1939. Under his editorship and inspiration some two hundred text-books were published, many with him as co-author.

In the years when science was becoming an increasingly important subject in the schools, this comprehensive series of text-books covering elementary and advanced courses was a contribution of great value. Gregory devoted himself to this work, and many authors, young and old, were grateful for his encouragement and his wise advice and criticism. Editorship for him meant a working partnership with the author at every stage of a book.

But his interest in education did not end with writing and editing books. He was keenly interested in the technique of teaching, in the many problems to be found in the introduction of what was often a new subject and in securing the proper place for science in the curriculum. It was these wide interests that led him to take such an active part in the formation of Section L (Education) of the British Association in 1901. He was its first secretary and then its recorder, and one of its most active members from the start. The turn of the century had seen a big extension of school science and many experiments were being tried.

Gregory, in his presidential address to Section L, when it came of age in 1922, gave a sketch of its aims and progress. It had been formed to devote attention to education in all its branches with the object of introducing scientific conceptions into every sphere of educational activity. Gregory defined the business of education as the promotion of the right

adjustment of a growing human being to its environment. The scope and character of the subjects of instruction should be determined by this biological principle and must be adjusted to new conditions in the world. "Science has become a kingdom potent with possibilities for good or evil—an inheritance which cannot be renounced—and to let any children grow up unfamiliar with their entailed possession is to neglect an obvious duty. . . . Science permeates the atmosphere in which we live, and those who cannot breathe it are not in biological adjustment with their environment—are not adapted to survive in the modern struggle for existence."

Gregory knew the kind of science teaching he wanted to see in schools; its purpose was not "to prepare for vocations but to equip pupils for life as it is and as it soon may be".

He was chairman of a British Association Committee in 1917 which was appointed to report on the essential place of science in school education. It included among its members several outstanding teachers like Sanderson of Oundle and Archer Vassall, and the report with its suggestions for science courses was the foundation of the movement towards general science. Gregory insisted that general science should be more than an amorphous collection of topics from physics and chemistry with a little natural history thrown in as a sop to the biologists. "It should provide for good reading as well as for educational observation and experiment; should be humanistic as well as scientific. The subject which above all others has the double aspect is geography. . . . Rightly conceived, geography can be made the earliest means of education as both Comenius and Locke regarded it, and it can be used as the unifying principle of all the generalized scientific instruction in schools." To-day with our greater knowledge of the world's resources and demands, of the needs of backward countries, of the principles of nutrition and disease, Gregory's forecast is seen in a new light.

He was very critical of examination syllabuses of the type of university entrance examinations which meant sacrificing the needs of the many to the interests of the few. While recognizing the value of laboratory work as a training in method, he was insistent on its being accompanied by broad courses which would excite wonder and stimulate the imagination, while providing a knowledge of everyday phenomena and the applications of science. His address was a plea "for the expansion of scientific instruction in this humanizing spirit, and for widening the gateway into the land of promise where the destinies of the human race are shaped. . . . I want science not only to be a means of stimulating real and careful thinking through doing things, but also a means of creating interest and enlarging the working vocabulary of the pupils and thus truly increasing their range of intelligence. So may scientific instruction be made a power and an inspiration by giving, in the words of the Book of Wisdom (vii, 16–20):

"An unerring knowledge of the things that are,
To know the constitution of the world and the operation of the elements;
The beginning and end and middle of time,
The alternations of the solstices and the changes of seasons;
The circuits of years and the position of stars;
The nature of living creatures and the raging of wild beasts,
The violences of winds and the thoughts of men,
The diversities of plants and the virtues of roots."

The late Poet Laureate shared Gregory's views. He spoke at the great meeting that was held in May 1916 to direct attention to "The Neglect of Science" which was prejudicing in many ways our war effort. It is probably scarcely even a memory to many; but the recollection of it is a reminder of the progress we have made since then, thanks in no small degree to Gregory's persistent advocacy. Robert Bridges in his final sentence crystallized the inward significance of this new view of scientific learning in the schools. "It is," he said, "the living grammar of the universe, without which no man can ever hope to read in its full significance the epic of his spiritual experience."

For his presidential address to the Science Masters' Association in 1928, Gregory chose as his subject "Contacts of Science and Literature". "As my main functions in life," he said, "seem to be those of a scribe and guide, it is perhaps appropriate that in this address I should deal with language and literature in relation to science rather than with scientific education or progress." Gregory was an omnivorous reader all his life and he had a good literary memory. He begins by comparing the outlook of the scientist and the poet, the one desiring to see things as they are, the other to display the emotional feelings aroused by them. But as Gregory shows by quotations from Tennyson and Shelley, their intentions are not necessarily opposed. Scientific truth may often be turned to poetic purpose. He quotes the verse from "The Cloud":

"I am the daughter of earth and water,
And the nursling of the sky;
I pass through the pores of the oceans and shores;
I change, but I cannot die."

Those lines had often been set for comment in elementary science examinations, and Gregory wonders whether students of English could interpret them so successfully. That leads him on to question whether the indifference to science among the teachers of English is not more general than the neglect of literature by students of science. Gregory was always pressing for a balanced education, and he resented the intransigent attitude of scholars and writers educated in classical schools towards the claims of science to an essential place among the new humanities. He rejects on the evidence of the psychologists the concept that the exercise of the mind on one kind of material improves the faculty to deal with all kinds of material, part of the basis of the claim that training in the classics is of unique value. But Gregory was a Hellenist with a deep appreciation of "the passionate regard for truth, disinterested research, imagination, acute reason and creative intelligence, which were the essence of the Greek spirit". He admits that "to certain minds a grammatical generalization is more readily understood than a principle derived from laboratory measurements, and on that account some pupils who have been trained to apply scientific method to language may be better prepared to take up the study of science seriously than those in whose minds are nothing but loose ends". What judgment could be fairer? And he ends with an appeal to teachers of English, classics and history to understand and interpret the human contacts of science with their own subjects, resulting in "a unity of interest which will give power and a new meaning to all cultural effort".

His book "Discovery" was one of Gregory's many services to education. Published in 1906, it ran

through many editions until in 1949 Gregory revised and shortened it for the Penguin Press, so that the younger generation will not read it in its original form. This I regret, as it had a quality of its own in giving a picture of the working of the minds of the great discoverers. Instead of following the historical sequence, Gregory's chapters deal with the different aspects of discovery: outlook and endeavour, the scientific mind, belief and evidence, law and principle, scientific motive and practical purpose. The book is a revelation of his wide reading, of his first-hand knowledge of the classics of science and of his amazing literary memory. It is interspersed with long quotations from the classic authors which are so aptly chosen that they fall imperceptibly into line with his own lucid lively sentences, while revealing the thoughts of many of the greatest scientists of the past and the literary quality in which they found expression. The quotations at the head of each chapter show, too, Gregory's range and discernment. The book has such freshness and vitality, it arouses human interest on every page, it is written with such zest and enthusiasm that it should be reprinted in its original form.

Sir Edward Salisbury, a few weeks ago, when he was opening the new biological laboratory of the University College of the South West of England, spoke of the present-day danger of specialization of the young scientist confined within the ever-growing complexity of his own field. Gregory's appeal was for some knowledge of the purpose and accomplishment of science by the young layman. His book "Discovery" seems to me so admirably suited to meet this dual need as an introduction which will arouse interest and stimulate wider reading. Gregory carried in his mind the whole story of discovery through the ages, he knew the personalities of the great men and their writings, and so with the touch of the journalist at his best, carrying his learning lightly, he has given us this vivid picture of the different aspects of the advance of knowledge. Astronomy, geology, biology, chemistry and physics are all woven together, as he drew his examples from the old masters and the new.

## Journalism

Almost from the day that Gregory became Lockyer's assistant in 1889 he was writing popular articles on astronomy, and Lockyer was quick to see the qualities—his lucid style, his gift of phrase, his sense of the significant—that were to make Gregory the greatest scientific journalist and editor of his time. Love of science and an imaginative sense of the part it was destined to play in human affairs were the mainsprings of Gregory's life. But in addition he had the shrewdness and the practical judgment, sharpened by his early struggles and adversity, which helped so much in the success of his editorship of *Nature*. Of all his presidential addresses—and he must easily hold the record both for their number and the variety of their subjects—his address on "Science and the Press" to the Association of Special Libraries and Information Bureaux (now Aslib) at Oxford in 1934 is in some ways the most significant as it contains a searching analysis of the parts an editor and a manager must play in the life of a newspaper. It reveals how his keen mind had appreciated the factors that make for success or failure. It is interesting to compare it with the terse crisp sentences in which C. P. Scott wrote "On Journalism" in the centenary number of the *Manchester Guardian*. The two men thought alike. "In all living things," wrote Scott, "there must be a certain unity, a principle of vitality and growth. It is so with a newspaper, and the more complete and clear this unity, the more vigorous and fruitful the growth. . . . A newspaper has two sides to it. It is a business, like any other, and has to pay in order to live. But it is much more than a business; it is an institution; it reflects and influences the life of a whole community; it may affect even wider destinies. It is, in its way, an instrument of government. It plays on the minds and consciences of men." *Nature* under Gregory certainly became an institution, both in the international and in the national fields, for he made it a clearing-house for new ideas. A letter to *Nature* became the accepted channel of rapid communication to the scientific world of a preliminary note of some new technique or discovery. But that was only one of its functions.

Lockyer made Gregory his assistant editor twenty-four years after he had founded *Nature*. As years went by, more and more of the work fell to Gregory and he was virtually editor a long time before Lockyer resigned the office to him in 1919. Gregory had his own ideas, and new features were introduced, like the leading articles, the first of which appeared in October 1915 on "Science in National Affairs". From November 1919 when he took over, they appeared every week, many from his own pen, dealing with scientific developments which had national importance. Some of their titles in 1919–20 indicate Gregory's wise discrimination and foresight in the subjects he chose: the nurture of key industries, the need for aircraft research, the organization of scientific work in India, meteorology and the State, science and the new Army, the cost of scientific publications, the present state of the dye industry, naval education, aerial navigation and meteorology.

The years of Gregory's editorship saw an immense increase in the number of scientific workers and a rapid growth of specialization with the increasing complexity of problems in each field. Entirely new fields of investigation were opened with new techniques, and there was a great extension of industrial research. All this combined to make it more difficult to watch developments all over the world. But under Gregory's skilful guidance *Nature* made this possible.

The late Lord Rayleigh, in thanking him for his Hinchley Lecture to the Institution of Chemical Engineers, on "Scientific Knowledge and Action", spoke of the great debt that all scientific men owed to Gregory for more than a generation. Looking back on his own scientific life, he said that he found it difficult to imagine how he could have carried on if he had not had the constant privilege of reading the pages of *Nature*, a journal which kept one in touch with science in all its branches. I remember very well as a schoolboy being introduced to *Nature* by H. B. Baker—"dry reaction Baker"—and I read it eagerly each week. When I returned from a scholarship examination at Oxford, Baker greeted me by saying, "Well, your reading of *Nature* must have paid a good dividend", and from my point of view it certainly had.

Lord Rayleigh spoke of the nice discrimination with which *Nature* avoided any reference to discoveries like the death ray which were trumpeted in the daily press, and his own reliance on the authority of *Nature*. He wondered how Gregory managed to keep in touch with all branches of science in all countries; "but somehow or other the thing was

done and scientists as a whole were glad to benefit by the result, even if they were mystified by the process".

In his early years Gregory stood almost alone as a scientific journalist, and in his Aslib address he lamented the scant encouragement given to science writers, since so few newspapers or periodicals had on their staff someone capable of dealing intelligently with scientific subjects, of equal standing with their special critics of art and music, or of racing, golf and tennis. As a result the public lack in science the enlightened guidance they receive in other matters. "Most people have yet to learn," he said, "how and why science and scientific thought are the determining factors in the chief problems of progressive life."

Gregory admitted that one difficulty was that many investigators were too busy and were often ill-fitted to be popular interpreters, which made it all the more important that there should be a class of science writers with some organization behind them, like Science Service, the non-profit-making corporation in the United States, founded in 1921 by a newspaper editor and proprietor, the late Mr. E. W. Scripps. He ended with an appeal to the press and to the men of science to get together and find a remedy.

That address was given nearly twenty years ago, and Gregory's advice has not gone unheeded. Particularly in the B.B.C. much has been done to make the public realize the outlook of the scientist and the impact of his work in almost every field of social and political well-being. Gregory took an active interest in establishing the Association of British Science Writers, of which he was the founder president.

It needed the experience of a Second World War to drive home the lessons of the First, but that demonstration of the power of science left in the minds of many a deep mistrust. Gregory himself repudiated the use of the atom bomb as repugnant to the ethics of the civilized world.

## British Association and British Science Guild

Of the many attachments Gregory formed during his life the longest and the most intimate was his membership of the British Association, and it was there that he was best known to the younger generation. He joined as a life member in 1896 and his attendance came near to being proverbial. In his telegram last year to us at Belfast he spoke of unbroken attendance at fifty-two meetings. From the first he threw himself into the work of the Association with immense energy and devotion, not only in Section L, but also on endless committees and as a member of Council for many years. He was always ready with constructive suggestions and he was one of the stalwarts who gave continuity to our meetings. The B.A. owed much to Gregory, but the debt was amply repaid when at the meeting in South Africa in 1929 he met in Johannesburg his future wife. She, too, has won our affection by her devoted care of her husband, who relied more and more upon her as years went by. Let me quote Gregory's own tribute to her: "My dear wife Dorothy has brought into my life more happiness than anyone else and whatsoever I may possess when I am called away cannot be more than a poor return for her sweet love and tender care".

But much as Gregory believed in the British Association, he followed Lockyer in thinking that its activities should be extended to influence public opinion and promote closer contact between science and public affairs.

In his presidential address at Southport in 1903 on "The Influence of Brain-Power on History", in which he paraphrased the title of Captain Mahan's famous book which did so much to arouse public interest in the Royal Navy, Lockyer urged the need for an organization to enable science to speak with a collective voice, so that it might counter the neglect which had become so dangerous, when Britain's industrial and military strength were both threatened with severe competition from abroad, competition based on education and scientific research. Lockyer gave striking figures to show how science was being starved in Britain as compared with the large sums being spent in Germany and the United States on the endowment of universities and research. He quoted Huxley's dictum that we were in the presence of a new "struggle for existence", a struggle in which science and brains take the place of swords and sinews, the result of which would be decided in the school, the university, the laboratory and the workshop.

It is perhaps difficult for the present generation to realize how backward we were. The total annual Government grant to universities and university colleges in Great Britain in 1905 was £155,000, while the University of Berlin ten years earlier was receiving £167,000. Lockyer pleaded for a duplicate of the Navy Bill of 1888 when £21½ million were voted for a five-year building programme.

Quoting the last words of the original objects of the British Association—"to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which might impede its progress"—Lockyer argued that here was a great opportunity to expand its functions. "This magnificent, strong and complicated organization would become a living force, working throughout the year instead of practically lying idle, useless and rusting for fifty-one weeks out of the fifty-two so far as its close association with its members is concerned."

However, the Council did not see its way to set up such a wide organization as Lockyer had outlined, possibly doubting the wisdom of becoming involved in national and political affairs. So the British Science Guild was formed in 1905, with Lord Haldane as its first president, with the objects of creating a general awareness of our future dependence on scientific method and research, of pressing for greater support for universities and research institutions, and of bringing to the notice of Parliament the scientific aspects of matters affecting the national welfare.

Gregory was at first a little doubtful about this breakaway from the Association; but he soon saw the advantages of the Guild as an agency for propaganda, backed by men in public life like Lord Haldane, Lord Sydenham, Lord Montagu of Beaulieu and Lord Melchett. By public meetings, by reports of committees, by lectures and by close contact with members of Parliament, it was able to stimulate public interest continuously during the critical years of scientific development. Some twenty urgent national problems concerned with scientific effort were investigated by strong committees, and in this way the Guild made a major contribution towards a number of improvements, among them: the Treasury grant for developing a National Physical Laboratory; the creation of the Development Commission for Agriculture; the establishment of a Department of Scientific and Industrial Research; the Patent Act of 1932; and the formation of the Parliamentary Science Committee.

In all of this Gregory soon became the moving spirit, and from 1922 he was chairman of the Executive Committee. He drafted many of the reports, and the work of the Guild had strong support in *Nature*. He organized the exhibitions of British Scientific Products in 1918 and 1919, for which he received the recognition of a knighthood.

There is no doubt that the Guild did most valuable work, and the Norman Lockyer and Alexander Pedler Lectures founded in 1925 and 1929 were a constant reminder of the importance of science in human progress. In 1923, when the first suggestion was made to unite the Guild and the Association, Gregory was opposed to it, as in his view the two bodies were essentially different. "The B.A. consists of priests and noviciates of science, while the B.S.G. represents a missionary effort to proclaim a new gospel." Negotiations were renewed from time to time, and finally in 1936 proposals for amalgamation were approved by the British Association at the Blackpool meeting. In 1938 the Division for Social and International Relations of Science was formed with a committee embodying the existing British Science Guild Committee, with powers to hold meetings not necessarily confined to the annual meetings of the Association, and a new journal, *The Advancement of Science*, was substituted for the old annual report.

It is true that the Division under Gregory's presidency kept the Association active during the War. But looking back at what the Guild accomplished and looking forward to the problems Great Britain has to face, I question whether the fusion was in the best interests of science. Has not Gregory's original objection been fully justified by the results ? The Guild could enlist the sympathy and leadership in the cause of science of men in public life. It provided a forum where a group of men of affairs could discuss with men of science. Under Lockyer's and later Gregory's watchful eye it could and did address itself immediately to national problems when science was concerned. Its success in later years was due largely to the energy and vision of Gregory and his friends. It was not only a missionary but also an invaluable watchdog. Has its offspring, the Parliamentary and Scientific Committee, effectively taken its place ?

## The Visit to America

In December 1938, just as he was leaving the editorial chair of *Nature*, Gregory was invited to give a series of lectures in the United States at the Carnegie Institution, Columbia, Harvard and Johns Hopkins Universities, and to address our sister body, the American Association for the Advancement of Science.

The tour was a great success, for Gregory was at his peak in his seventy-fifth year as an eloquent exponent of the gospel of science, and he felt the thrill of the occasion. He had seen clouds gathering on the horizon and his addresses were a declaration of his faith in what science could contribute to a disordered world if it were not perverted to destructive uses in the lust for power. Gregory feared the growing tide of nationalism as a disintegrating force in a world which science could help to unify. In 1938 he recalled Soddy's Cassandra-like prophecy of the atom bomb.

The Greeks had dreams of the Golden Ages of the past, they had no word for progress ; but Gregory had visions of the Golden Ages of the future, if man would use his new understanding of Nature to good purpose.

His Elihu Root Lecture to the Carnegie Institution of Washington, on "Cultural Contacts of Science", was the most finished and carefully argued of all his addresses, and it gave the best picture of the run of his mind and interests. It deserves to be reprinted, as it is unknown in his own country. In it he counters the view that scientists are materialists, insensitive to beauty and incapable of deep emotion, that the scientist's idea of the evolution of mankind is the law of the jungle, "Nature, red in tooth and claw". Through all his American addresses there runs the motive of his favourite quotation from Huxley, his dean at South Kensington, in "Evolution and Ethics" : "In place of ruthless self-assertion it demands self-restraint in place of thrusting aside, or treading down or competition, it requires that the individual shall not merely respect but shall help his fellows ; its influence is directed not so much to the survival of the fittest, as to the fitting of as many as possible to survive".

The future of the world depends, Gregory said, on the use of science in the spirit of the Sermon on the Mount.

One of the themes of the Elihu Root Lecture was the relation of science and literature. He quotes fine passages from Kepler and Newton, examples of de Quincy's "literature of power" as contrasted with "literature of knowledge", which "survive because of their human feeling naturally expressed". He quotes the famous passage in Wordsworth's introduction to Lyrical Ballads : "Poetry is the wealth and fine spirit of all knowledge . . . it is the impassioned expression which is in the countenance of all science". "Poetry," says Gregory, "and other forms of literary and artistic expression once followed more closely on knowledge than they do to-day. . . . Poetry, philosophy and science all began life together as children of one family. . . . The greatest singers of antiquity were the most alive to science." Then he turns to the history of the earliest science, astronomy—"The science most closely associated with spiritual feeling", and traces its relationships through the ages to religion and other reflexions of current thought in literature and philosophy. He follows the gradual emergence of the conception of law and order to Nature and of divine purpose through the study of celestial bodies in Babylon, in Egypt and in Greece. Then from his knowledge and love of literature he illustrates the inspiration that came from man's contemplation of the skies in the Bible and in the poems of Virgil and Lucretius, of Dante, Chaucer and Milton.

Through all this Gregory is tracing the pursuit of truth and its high moral and spiritual influence in whatever field it is the motive of action. Science is not to be regarded, "merely as a store house of facts to be used for material purposes, but as one of the great human endeavours to be ranked with arts and religion as the guide and expression of man's fearless quest for truth".

When he returned from America, Gregory collected all the materials for his lectures and embodied them in a book, "Religion in Science and Civilization". This was published in 1940, but alas nearly all the copies were destroyed in an air-raid, and then with his energy unabated at the age of eighty, he set to work and recast it under the title of "Gods and Men", which was published in 1949. Among the many appreciative letters he received about the book,

those from Dr. George Trevelyan and Mr. Mackenzie King gave him special pleasure. Dr. Trevelyan said he was astonished that one who had given his life to science should have been able to take so wide and deep an interest in history. "I see you are a great age now which makes my wonder of the book all the more." Mr. Mackenzie King, writing just after his resignation of the premiership of Canada, said that the book had given him what he most needed—"A place of new beginning; something to restore a true perspective".

## Presidency of the British Association

In 1939 came the Second World War and Gregory had been elected president at Dundee the day before war broke out. The annual meetings of the Association had to be abandoned, but the formation of the Division for the Social and International Relations of Science gave the opportunity under Gregory's leadership for a series of conferences to discuss questions that would be in urgent need of solution when the War ended. The ideas of the founders of the British Science Guild were thus given scope for expression and action. There were eight conferences in all over which Gregory presided, and at the first, on "Science and World Order", he enunciated a "Declaration of Scientific Principles" which was in effect a Hippocratic Oath for scientists.

These conferences kept the Association in action during the War and they certainly achieved their object in providing opportunities for the discussion of post-war problems. Their subjects covered a wide field and perhaps the most successful were those on mineral resources, the place of science in industry, and science and the citizen, at which Gregory read a paper on "Science and the Press", in which he emphasized the need for continued education on the impact of science on social relations.

Gregory's was the record presidency of seven years, from 1939 until 1946, when he delivered his presidential address at the first short post-war meeting in July. His subject was "Civilization and the Pursuit of Knowledge". In it he recurs to the favourite topic of his later years, the gradual emergence of civilization through the ages and the history of early religion with its close association with the heavens. Then he outlines the development of the schools of philosophy and the growth of natural knowledge, science and invention. Gregory's anxiety was the use that man might make of his new powers, and he ends with a moving appeal for goodwill and goodness of heart in the choice between the good and evil fruits of knowledge.

His last speech to the Association was at Birmingham, when he moved the vote of thanks to Bishop Barnes for his Sunday evening discourse on "Science, Religion and Moral Judgments". The Bishop's subject was close to Gregory's heart and he was at his happiest in his appreciation of the address, with all his old zest and enthusiasm and his readiness to find *le mot juste*. We saw him for a brief space at Edinburgh, where he was taken ill; for a year he was an invalid and then in September 1952 his active spirit quietly flickered out.

## Epilogue

I began with the idea of making this lecture mainly a study of the times of Richard Gregory, but I quickly found those times becoming just a background to the human interest of his life of endeavour and success—a success which is so encouraging a story in the days when there were few of the educational escalators of the present time. I have told the story so far as possible in his own words, which were so well chosen.

Gregory's long life of nearly ninety years saw the most rapid and eventful changes in the outlook and fortunes of mankind. First came the battle between the evolutionists and creationists and the emergence of the liberal interpretation of the Holy Scriptures that we know to-day. Next came the gradual recognition of our social responsibility for the human adjustments that are needed in an industrial civilization, which has changed so profoundly the social structure of Britain. Alongside them came that pride of discoveries, the electron, the nucleus, the quantum and relativity, that have given a fresh insight into the nature of matter, of life and of the universe. With that deeper insight has come a new humility in response to the ever-receding vistas of the complexity of the unknown.

With the advance of knowledge came a new power of man over his environment, the possibility of a new partnership with Nature in place of the struggles of primitive man. Evolution has moved fast, quickened by the needs of two world wars, that have left such deep scars behind them.

Of all this Gregory, so far as science was concerned, was the interpreter, or as he called himself once 'the standard bearer', and he had ideal qualities for the task. He was no specialist, nor in that sense a profound thinker; he did not engage in the details of polemics. He saw the broad picture and its human bearings, for he was essentially a humanist. He had the gift of leadership—persuasive, resourceful and quick in action. He had a ready humour and a fund of stories. But above all he was one of the most generous of men, generous in his help and gifts, generous in his praise, and sometimes too generous of other people's motives.

Success and recognition came to him in many ways and he enjoyed them to the full. It was his generosity towards others that made his successes such a pleasure for his friends. The honours that pleased him most were his knighthood and his baronetcy, his election to the Royal Society under Statute 12 in recognition of his conspicuous service to the cause of science, his election to the Athenæum under Rule II, his honorary membership of the Old Cliftonian Society, the presentation to Lady Gregory and himself from the British Science Guild, and finally his presidency of the British Association.

Gregory was an optimist: he saw the best in everything and everybody. This made him sympathetic to new movements, which seldom came to him in vain for help. Perhaps, too, it was partly the inveterate old journalist in him peeping out, eager for news. From first to last he was a member of more than seventy societies and institutions and a moving spirit in so many. But it is as the editor of *Nature* that he will be best remembered in the future, for his wise, shrewd, imaginative guidance that gave *Nature* its unique position in the scientific literature of the world. The driving force behind all he did was his devotion to the interests of science and his belief in its message for the future. Gregory wrote his own epitaph:

> "My grandfather preached the Gospel of Christ;
> My father preached the Gospel of Socialism;
> And I preach the Gospel of Science,
> But the ethical principles of all three are
> pursuit of truth and righteousness for the
> improvement of man and society."

# STORAGE OF NORMAL TISSUE GRAFTS

A SYMPOSIUM, under the chairmanship of Dr. A. S. Parkes, on the "Preservation of Normal Tissues for Transplantation" was held in the rooms of the Ciba Foundation during March 16–18, 1953. Like other colloquia organized by the Foundation, its purpose was to provide not merely for the formal presentation of scientific papers but also for the informal discussion of problems of common interest to the participants. The symposium kept closely to the subject defined by the title; tumour transplantation was left aside because tumours are 'abnormal', and the storage of semen because semen is not a tissue.

Tissue storage, for practical medical purposes, is a storage of spare parts for surgical replacement. It is possible to envisage situations in which a patient's tissues might be stored for his own future use—for example, a surgeon might deliberately remove a little more skin than was necessary at an orthodox grafting operation, and keep the excess in store in case some of the grafts he actually used failed to heal properly—but for nearly all practical purposes, storage for replacement surgery entails the use of tissues from other human beings. This being so, the surgical use of stored tissues is bedevilled by the fact that some living tissues will not form permanent grafts after transplantation from one individual to another. They elicit immunity reactions which end by destroying them. Problems of tissue storage are thus closely interwoven with problems of tissue transplantation immunity.

In opening the scientific proceedings, Prof. P. B. Medawar (University College London) said that living skin, when transplanted into positions formerly occupied by skin, was probably the most exacting of all tissues in this regard; skin so grafted between one adult and another did not survive longer than a few weeks. Other tissues enjoyed special dispensations from the rigours of transplantation immunity, the nature of which could only be understood if the normal process of immunity were first defined. There is no doubt at all that intolerance of homografts had the properties of an actively acquired immunity reaction, but a reaction of what particular kind? A certain combination of properties points unmistakably to membership of that class of immunity reactions of which tuberculin sensitivity and sensitization to simple chemical compounds were also members. The most recently discovered of these properties, so Mitchison had found, was that immunity could be passively transferred by living cells but not by serum.

A homograft could be made more acceptable to its host either by changing the antigenic propensities of the graft or by modifying the reaction of its host. Under the latter heading, Prof. Medawar outlined experiments done in collaboration with R. E. Billingham and L. Brent which showed that if an animal were presented with living foreign cells in fœtal life, its power to react against those cells in later life was reduced or wholly abolished. This was not due, as had been widely assumed, to an adaptation of the grafted cells, but to an adaptation of the host, for 'actively acquired tolerance', once established by inoculation of the fœtus, extended to cells freshly transplanted in later life—cells which therefore had had no opportunity to adapt themselves to alien soil.

Dr. W. P. Longmire (University of California and U.S.A.A.F.) proceeded to survey the clinical uses of tissue homografts in general. One could make a broad distinction between homografts which had to be alive if they were to serve a permanently useful purpose, and homografts which could act as a guide and sometimes a stimulus to natural regeneration irrespective of whether they remained alive or not. Skin and endocrine glands came pre-eminently into the former category, of 'homovital' grafts. 'Homostatic' grafts included those of artery, bone, cartilage and possibly cornea. Grafts of some of these tissues did not even have to be alive on transplantation, but corneal grafts which were dead on transplantation had not given successful results. Dr. Longmire mentioned that plastic substitutes behaved differently from homostatic grafts: they might be tolerated by, but were not incorporated into, the body. Turning to experiments on fundamental problems, Dr. Longmire said that he and his colleagues were engaged with studies on the success of skin transplantation in chicks as a function of age. A small proportion of skin homografts were successful when exchanged between newly hatched chicks of different breeds; but the proportion of successes fell off rapidly to zero by the time the chicks were two weeks old. By holding the age of the recipient constant, it had been found that younger skin had somewhat less power to provoke immunity than older skin.

Dr. J. W. Pate (U.S. Naval Medical Centre) adopted Dr. Longmire's classification of homografts, and said that, inasmuch as certain homografts did not have to be alive on transplantation, their storage in the living state raised unnecessary complications. Some storage treatments entailed chemical modification of the grafted tissue; generally, storage by freezing or freeze-drying was therefore to be preferred. Experiments showed that vitality of arterial homografts was not merely unnecessary but undesirable: frozen-dried arterial homografts were superior to fresh living homografts, and frozen-dried bone was not inferior to living bone. Frozen-dried skin could be used as a homostatic graft for providing a temporary physiological dressing for raw areas on severely burnt patients, in full recognition of the fact that they contained no living cells. Frozen-dried skin was as useful as a living skin homograft for such a purpose.

Dr. W. R. Earle (National Institutes of Health, Bethesda) described his methods for cultivating tissues *in vitro* in large quantities and for long periods. Such mass cultures could be started from single cells grown in capillary tubes, and might be subdivided into sublines which proved to have different properties; nor was growth confined to 'two-dimensional' sheets, for the incorporation of glass helices into the medium provided a framework for solid growth. Dr. Earle had cultivated human skin for 1½ years *in vitro*, and one such culture attained a total area of 1,600 cm.²; he emphasized the tremendous possibilities for research which such materials and techniques now placed at the investigator's disposal.

The second session of the conference was concerned with the problem of storing and grafting endocrine tissue. Dr. Parkes (National Institute for Medical Research) began with a paper by Dr. Audrey Smith

and himself on ovarian grafts. Early experimenters, he said, had approached the problem of endocrine homografts with complete disregard of immunological complications, and whether this attitude were wholly justifiable or not, he himself was convinced that endocrine homografts were both practicable and effective. Ovarian tissues impregnated with 15 per cent glycerol in normal saline and slowly frozen to − 190° C. did not deteriorate after a year's storage; when thawed and transplanted into ovariectomized recipients, vaginal œstrous cycles were restored. Rat testes, and probably the pituitary, could be stored in the same way, but the adrenal gland had proved more difficult.

This work was concerned purely with the endocrine activity of stored ovarian tissue; Dr. R. Deanesley (National Institute for Medical Research) considered the degree to which it retained its gametogenic power. Small pieces of ovary from 7-day old rats were frozen and later grafted into older recipients; nearly all the ova had disappeared twenty-four hours later, but healthy follicles could be identified in specimens removed for microscopic examination after 6–10 days. These follicles increased in size with age, and became prematurely luteinized. Similar experiments with frozen testis material showed that it, too, survived such treatment: it remained capable of maintaining histological structure of the seminal vesicles of castrated hosts and gave evidence even of sperm formation.

Dr. P. J. Gaillard (Leyden) recapitulated the results of earlier experiments of his which showed that fœtal tissues could acquire differentiated functional activity if cultivated in media derived from older animals. These experiments opened up the possibility of using endocrine grafts originally derived from fœtuses. Human fœtal parathyroid glands had been maintained in culture for seven weeks, the last stages of cultivation being in media derived from their prospective recipients. The cultivated tissues were transplanted into perivascular tissues of patients who had shown signs of parathyroid deficiency after thyroidectomy. In a number of such patients the calcium and phosphorus levels in the blood were rapidly restored to the normal. Success was more common in the younger patients; all the grafts had failed in patients more than thirty-six years old. Dr. P. F. Jones reported that homografts of adrenal cortical tissue from rats, not more than two days old, could survive in mature adrenalectomized rats of a different strain and could keep their hosts alive for many months. The grafts were well vascularized and looked healthy; their hosts died shortly after the removal of the grafts, so showing that the cortical tissue was actively secreting adequate amounts of hormones.

The third session began with a consideration of the storage of blood. The preservation of even the most labile plasma components, Dr. P. L. Mollison (Postgraduate Medical School) said, was relatively simple. Transfused leucocytes soon left the circulation, so that the principal problem was the preservation of red cells. Red cells can be identified by their antigenic properties; their average life-span was about 115 days. Storage in citrated glucose at 4° C. gave poor results after about a month; maintenance of a *p*H of 7·2 improved the results, and sucrose could be used to delay hæmolysis without, however, improving the survival of red cells after transfusion. Dr. Mollison particularly emphasized the fact that the non-occurrence of hæmolysis or visible abnormality after storage did not by any means guarantee the prolonged survival of red cells after transfusion.

The incorporation of glycerol into storage media made possible the use of storage temperatures far below zero, and therefore storage for long periods; but great practical difficulties were introduced by the need for removing glycerol slowly from red cells stored in bulk. Although there was always some loss of cells on storage at very low temperatures, the deterioration did not increase as storage was prolonged. Dr. Mollison said that transfused red cells sometimes failed to survive, and he wondered whether a reaction akin to that provoked by living nucleated cells could be responsible.

The best rates for freezing and thawing tissues to ensure their survival, and the remarkable protective powers of glycerol, were all discovered and worked out by pure empiricism, sometimes (as with the choice of slow freezing in preference to fast) in the face of expert theoretical advice to the contrary. Dr. J. E. Lovelock (National Institute for Medical Research) considered the biophysical aspects of the process of freezing and showed to what a large extent a reconsideration of the theoretical background of the process had justified the empirical choice of methods. The effect of glycerol was to reduce the range of temperature over which cells were particularly susceptible to damage during freezing; its efficacy depended among other things on its complete non-toxicity, its low molecular weight and free passage across cell membranes; very few other compounds, if any, had just the right combination of properties.

Dr. C. M. Pomerat (University of Texas) had been engaged in an attempt to interpret the behaviour of tissues in bulk during changes of temperature into the responses of individual cells. Apparatus had been devised which made it possible to combine continuous thermal and photographic recordings of cultivated cells—particularly those of human nasal mucosa—under various conditions of thermal stress. The forms of mitochondria and the vigour of intracellular movement were sensitive indicators of a cell's well-being under such conditions. Describing the effects of glycerol, Dr. Pomerat illustrated the vigorous cytoplasmic bubbling consequent upon a rapid transition from glycerol to normal saline solutions. Pinocytosis and nuclear rotation were also illustrated; further study would probably show that these also served as delicate indicators of departures from normality of behaviour.

Dr. R. E. Billingham (University College London) began the fourth session by describing the storage of skin. After impregnation with glycerol solutions, skin slowly frozen to − 79° C. did not deteriorate in any way after even ten-months storage; used as a graft, it was indistinguishable from an unstored normal skin graft in fine structure, colour, epithelial growth-rate, and differentiation of glands and hairs. Such criteria of normality were much more rigorous than those based on mere cellular survival. Melanocytes were much more exacting than Malpighian cells in their storage requirements, and showed up the advantages of using glycerol particularly well. Skin did not survive desiccation from the frozen state below a final overall water content of about 25 per cent; claims that mammalian tissues could withstand a higher degree of dehydration had never been supported by actual estimates of residual water. Glycerol, Dr. Billingham pointed out, was negligibly toxic; even dissociated epidermal cells could with-

stand being suspended in 98·1 per cent glycerol at room temperature for half an hour.

Dr. F. K. Sanders (University of Oxford) described experiments on the use of nerve homografts. Frozen-dried homografts were capable of guiding regenerating nerve fibres across relatively large gaps in the nerve trunks of small laboratory animals, their endoneural collagenous tubes being systematically re-populated by Schwann cells and fibroblast cells deriving from the host. Fresh homografts elicited a typical homograft immunity reaction in which the vascular stagnation was particularly inimical to successful repair. Results with the use of nerve homografts in human beings had been particularly disappointing. Dr. Sanders argued that this was because the absolute size of such gaps was always larger in clinical practice than in experimental animals; since the time relations of the immunity reaction were not much different in the two cases, and the rate of outgrowth of fibres from the central stump much the same, the difference was probably due to the fact that in human beings the immunity reaction became effective before the regenerating fibres reached the peripheral stump.

The next two papers were concerned with the use of arterial homografts, among the most uniformly successful and rewarding of all those in clinical use. Prof. G. C. Rob and Dr. H. H. G. Eastcott, of St. Mary's Hospital, used normal human vessels, removed as quickly as possible after death and stored in the frozen state. Such grafts gave excellent functional results, the success of which depended neither upon the viability of the graft at transplantation nor upon its length; the new endothelial lining was formed as quickly in long grafts as in short, and they accordingly inferred that it was formed by cells derived from the blood stream and not by creeping invasion from the two ends of the graft. Dr. C. A. Hufnagel (Georgetown University) summarized several years experience with vascular grafts in clinical practice and in experiments with dogs. There was no clinical distinction between the success of fresh, frozen, or frozen-dried grafts, and even frozen-dried heterografts from calves and pigs had given clinically satisfactory results. But even frozen-dried grafts had to be removed and preserved aseptically; experiments still in progress suggested that ethylene dioxide was an efficient sterilizing agent which produced no significant alteration in the fine structure of the grafts.

In clinical practice, transplantation of the cornea must always be of necessity homoplastic, and it is now quite widely known to enjoy an encouragingly high expectation of success. Mr. B. W. Rycroft (East Grinstead) analysed the criteria of success. Mere healing, and even the restoration of translucency, were not enough: there must be improvement of vision, if the graft were done for other than purely cosmetic purposes or to prepare the cornea for a later definitive grafting. Lamellar grafts were safer and generally more successful than full-thickness grafts, in which the danger of infection became serious; but he believed that the optical virtues of the latter might be combined with the safety of the former by means of a 'flanged' graft, or full-thickness centrally but with a thinned rim. Mr. Rycroft believed that corneal grafts were replaced by the tissues of the host; but heterografts were generally unsuccessful, and plastic substitutes inefficacious. One of the chief practical difficulties was over supply. The Corneal Grafting Bill of 1952 had now at last made it possible for eyes to be bequeathed after death, and such eyes might be stored for perhaps two weeks under liquid paraffin; but a method of semi-permanent storage would clearly be of the greatest value.

The proceedings ended with Dr. W. R. Strong's (U.S. Naval Medical Centre) description of the working of the U.S. Naval Tissue Bank, instituted in 1949. The Bank made use of tissues aseptically removed after death and stored after desiccation from the frozen state to less than 1 per cent residual water. Skin, bone and blood-vessels were systematically removed in accordance with an exacting routine and stored after drying in sealed glass vessels. Frozen-dried bone, even in the form of coarse granules, had given encouraging clinical results, and so, in their more limited experience, had blood-vessels. Frozen-dried skin was used purely as a temporary physiological dressing: it relieved pain, controlled the loss of tissue fluids, and reduced the risk of infection.

The impressions left in the mind of one participant were these. 'Homovital' grafts (homografts which must be alive on transplantation and must remain so if they are to serve a useful purpose) are a well-defined category. The use of skin homografts in clinical practice must await a fuller analysis of the methods by which their putative recipients can be made to tolerate them. Such methods have already been discovered; but they are not yet clinically applicable, and it is not likely that anything but fundamental research will make them so. Endocrine homografts sometimes succeed, and treatment of endocrine deficiency by hormones has not yet stolen all the thunder their use might one day cause. At the same time, it would be unfortunate if the dispensation which allows them sometimes to survive where homografts of other tissues fail were not made the subject of thorough scientific analysis; the theory of endocrine homografting as such can at present only be pieced together most incompletely from research conducted with only endocrinological or clinical purposes in mind. Tissue storage will become of practical value when the difficulties of transplantation have been overcome. The storage of skin offers no particular difficulty; nor that of certain endocrine tissues—at least if ambitions fall short of storage in perpetuity. The different endocrine tissues may raise their own peculiar storage difficulties.

'Homostatic' grafts are a less well-defined category. Some must apparently be alive on transplantation, but need not remain so; others may be dead from the beginning; some, perhaps all, provide stimuli for regeneration which could not be imparted by plastic replacements; certainly all require that a certain integrity of fine organization should be maintained. The outlook for frozen-dried arterial grafts is most encouraging, and it may not be too rash to say that the practical problems raised by their storage and use are now in principle solved. Bone homografts, even after freeze-drying, show high promise of surgical use. Corneal grafting, from the nature of things, can only approach asymptotically to 100 per cent success: through no fault of the surgeon, it is at present the only tissue for which storage methods are badly in arrears of methods of transplantation. Scientific workers can help the ophthalmic surgeon by devising efficient storage methods and also by attempting to analyse the occasional failure of corneal homografts after promising beginnings: such failures may prove to be of immunological origin.

# RADIO AND THE CORONATION

CORONATION Day, June 2, was marked by the application of the whole of the modern technique of sound and television broadcasting to enable a vast number of people throughout the world to be in constant touch with the proceedings in London during this eventful day. In the first case, the resources of the B.B.C.'s sound broadcasting service were utilized to the full in providing, for a continuous period of seven hours, a direct commentary on the Queen's Procession from Buckingham Palace to Westminster Abbey, the service and ceremony of crowning in the Abbey, and the subsequent State Procession through London. This programme was provided as an integration of the descriptions given by expert commentators at nine points along the route and inside the Abbey and its Annexe. Apart from the radio transmission, this programme was relayed through loudspeakers to the many thousands of people who lined the route, so that in addition to seeing the procession when it passed them, they could follow by verbal description the entire course of the proceedings.

For the home sound broadcasting service, thirty-seven transmitters were used, with an additional forty-eight stations for the B.B.C.'s external services, by reception from which several hundred local stations relayed the programme regionally in many parts of the world. This involved the use of forty-three languages by the B.B.C. during the day: and furthermore, in order to satisfy the needs for world coverage, the Corporation provided about a hundred positions, with suitable 'effects' microphones, in the Abbey and along the processional route, for the use of other commentators. In this way a continuous and very effective sound picture of the Coronation proceedings was made available to countless millions of people in all parts of the world, and the many congratulatory reports received show that it was greatly appreciated.

## Television

But Coronation Day was also a historic event in the development of television in Great Britain. For the first time in history, not only the State Procession but also the whole of the actual ceremony of crowning inside the Abbey could be seen by millions of viewers all over the country through the television service of the B.B.C. With the aid of five cameras inside Westminster Abbey and several others at various points along the processional route, the television audience was enabled to follow the whole of the day's proceedings. All the television transmitters of the B.B.C. were in use, including the supplementary stations recently brought into service in the neighbourhoods of Belfast, Brighton and Newcastle. In addition to private viewing on domestic receivers, many arrangements were made for the benefit of larger audiences in halls, hospitals and other places. These included the Festival Hall in London, where the presentation of the entire seven-hour programme on a full-size cinema screen was described as excellent, and may be taken to record the arrival of television technique at the stage when it is available for the theatre-going public.

## Television to the Continent

The television service was not, however, confined to viewers in Britain. Following the experience gained last July, when for a week the B.B.C. broadcast part of the daily television programme from Paris provided by Radiodiffusion et Télévision Françaises, this time the British programme was transmitted by a series of radio links to the continent of Europe. In Paris the 405-line signals from London were converted to 441 and 819 lines for re-transmission by the television stations at Paris and Lille; and at Breda, in Holland, arrangements had been made by the Philips organization to convert the British video signals into a 625-line signal. This was then taken by additional radio links to the Eindhoven and Hilversum television transmitters in Holland; and also fed into the permanent network recently set up by the Nordwestdeutsche Rundfunk to link up the five or six television stations of that administration in Western Germany, including Berlin. The accompanying sound programme was transmitted independently by cable to the Continental organizations, where either the English language could be used or this could be translated by local commentators. This enterprise for the international relaying of television programmes has met with unqualified success. Tens of thousands of French people saw the Coronation ceremonies on television screens either in private houses or in the many windows and booths in Paris where television receivers had been set up in shops and newspaper offices.

## Service to North America

The technique of the subject has not yet advanced to the state where a direct television service can be established across the Atlantic to the vast potential numbers of viewers in North America on such an occasion as this. Careful examination had been made during the past year or more of proposals to relay the vision signals from high-flying aircraft or over a series of radio links, but even the vast resources of the United States broadcasting organizations could not render this a practical means of getting a direct 'live' view of the Coronation proceedings. An attempt was made in New York to receive the British television signals by direct transmission, but nothing suitable for introduction into the American television service was obtained. Failing this, the most rapid means of letting American viewers see the proceedings in London was by facsimile or photo-telegraphy transmission. Within twenty minutes of the crowning of Queen Elizabeth, pictures of the scene in Westminster Abbey were being sent direct from London into newspaper offices throughout the United States; and these pictures were transmitted over the television networks, so that millions of people throughout the United States could follow the ceremonies with the aid of the service of the B.B.C., which according to *The Times* correspondent "was received with unfailing power and clarity".

Furthermore, as the next best substitute to a 'live' television service, the two major American broadcasting networks (National Broadcasting Company and Columbia Broadcasting System) had Coronation films flown across the Atlantic in a Canberra bomber to Newfoundland, where other aircraft were waiting to take the films on to distribution points in the television networks of Canada and the United States. In this way viewers in North America were, owing to the difference in local times, enabled to have their

own view of the Coronation proceedings on the same afternoon as the events took place in London.

### General Appreciation

In one respect only does television technique on a public service basis lag behind the possibilities of the cinematograph film. The pictures are still presented in black-and-white, whereas anyone who witnessed the actual State procession will agree that the pomp and splendour of this could only be given an adequate appraisal by a presentation in full colour. In spite of this limitation, however, the radio correspondents of the daily Press have had nothing but praise and glowing terms of appreciation for the magnificent service given by the B.B.C. and all those connected with this organization, for an outstanding achievement in the history of broadcasting and television.

On the technical side, some thirteen hundred additional sound circuits and more than a hundred vision circuits in and around the London area were provided by the Post Office Engineering Department, working in co-operation with the B.B.C. engineers. It is probable that only those closely connected with the technical and programme sides of broadcasting can appreciate the immense complexity of the circuit and other arrangements necessary to collect together such magnificent programme material and disseminate it to the entire satisfaction of the recipients, public and private, all over the world.

Whatever may be the future of British broadcasting, there is no doubt that, on this occasion, the B.B.C. lived up to the reputation, acclaimed by many, of presenting the best public broadcasting and television service in the world.

# NEWS and VIEWS

## Physical Chemistry at Manchester : Prof. Geoffrey Gee, F.R.S.

Prof. Geoffrey Gee, who has recently been appointed to the chair of physical chemistry in the University of Manchester in succession to the late Prof. M. G. Evans, was born at Disley, Cheshire, and received his early education at New Mills Grammar School under the headmastership of Mr. W. A. Whitton. In 1928 he entered the Honours School of Chemistry in the University of Manchester under Prof. Arthur Lapworth ; here he obtained the B.Sc. and M.Sc. degrees and did two years work on electrocapillarity in the Thomas Graham Colloid Research Laboratory. In 1933 he joined the staff of the Dyestuffs Group of Imperial Chemical Industries, Ltd., and for five years he worked in the Department of Colloid Science at Cambridge in association with Sir Eric Rideal and later with Prof. H. W. Melville. During this period, alone or in collaboration, he published more than a dozen papers of a pioneering type on two main topics—oxidation and polymerization reactions in monolayers, and the kinetics of polymerization in the liquid phase. In 1938 he joined the British Rubber Producers' Research Association, and in 1947 he was appointed director of research in the Association. His publications in this period deal with olefin oxidation and, more especially, with the thermodynamics of polymer systems, in which subject, again, he did pioneer work which has led the way to a closer relation of thermodynamic properties to macro-molecular structure. Prof. Gee was elected a Fellow of the Royal Society in 1951 and in 1952 was awarded the Colwyn Medal by the Institution of the Rubber Industry. His return to his old University is warmly welcomed, especially by those who remember him there in his student days.

## Mathematics at Dundee

Prof. A. M. Macbeath has been installed in the chair of mathematics at University College, Dundee (University of St. Andrews). Prof. Macbeath, who is twenty-nine, was educated at the Royal Academical Institution, Belfast, the Queen's University of Belfast and Clare College, Cambridge. Graduating with first-class honours in mathematics at Queen's in 1943, he served from then until the end of the War as a junior administrative officer in the Foreign Office. At Cambridge he was a Wrangler in Part 2 of the Mathematical Tripos in 1946 and gained a mark of distinction in Part 3 in the following year. After a year's research at Cambridge on the geometry of numbers, he was awarded a Commonwealth Fund Fellowship in 1948. With this fellowship he continued his researches in number theory for two years at Princeton University, obtaining the degree of Ph.D. in 1950. On his return to Cambridge he was elected to a fellowship at Clare, where he worked until October 1951 ; he was then appointed to a lectureship in mathematics at the University College of North Staffordshire. In the following year he was promoted senior lecturer and played a major part in framing the courses in pure mathematics in the new College. Prof. Macbeath's contributions to pure mathematics are already substantial, and there is no doubt that he will add to them during his tenure of the chair at Dundee.

## Everest

One of the great challenges to the spirit of human endeavour in the field of exploration and determination to beat natural obstacles was overcome on May 29, when E. P. Hillary, of New Zealand, and Sherpa Tensing Bhutia, of Nepal, had successfully reached the summit of Mount Everest. This fine achievement by the members of Colonel H. C. J. Hunt's expedition is a noteworthy climax to a long series of attempts dating from the reconnaissance of 1921, and, with the news coming on the eve of the Coronation, the British people can take more than especial pride that their country has engineered this success. However, mountaineering, like science, is not a purely national affair, for it is practised by many peoples and, like science again, builds on the successive experience and knowledge gained by previous generations. First of all, tribute must be paid to the Sherpa porters, without whose courage and endurance this year's expedition—and all the previous ones—could never have started at all ; to them, too, falls the honour that one of their number made the final assault. The route followed this year is the comparatively new one from the south, first reconnoitred by Mr. Eric Shipton's party in 1951. The pre-war attempts were all on the northern side by way of Tibet, but that country is now closed to foreigners whereas, paradoxically enough, Nepal, which previously had been a forbidden country, now permits the passage of expeditions. The favourable reports of Mr. Shipton encouraged a Swiss team to make a

serious attempt last year, and they were almost successful, for M. Raymond Lambert and the same Sherpa Tensing got within 800 ft. of the summit. It is a great tribute to the Swiss party that, in the true spirit of mountaineering brotherhood and international co-operation, so characteristic of their country, they imparted all the hard-earned details of their climb to this year's expedition.

Finally, mention must be made of the part science and technology have played. It is no belittlement of the prowess of the climbers to say that without oxygen they would never have succeeded, and this year has seen the improvement of the 'open-circuit' oxygen apparatus and the novel development of a 'closed-circuit' apparatus; incidentally, it has been reported that the first assault with the latter type was unsuccessful and that Hillary and Tensing, who were the second pair to make the attempt, used 'open-circuit' masks. Then again, the developments during the past decade and more of synthetic materials, and the experience gained of the physiology of human exposure and acclimatization, together with other recent advances of science and medicine, have all played their part. Nevertheless, any expedition reduces in the end to a battle between man and Nature, and rash indeed would he be who would prophesy that in future man will always be the victor.

It has since been announced that Mr. Hillary has been made K.B.E. and Colonel Hunt has been created a knight; Sherpa Tensing is not a British subject and the question of recognition of his achievement is under discussion.

## The Wiles Lectures at Queen's University, Belfast

The Queen's University of Belfast has received a gift of £7,500, to be spent over the next 7–10 years, to promote the study of the history of civilization and to encourage the extension of historical thinking into the realm of general ideas. The gift is from Mrs. Austin Boyd, of Cultra, Co. Down. It is to be used to endow an annual series of about four lectures, to be known as the Wiles Lectures, in memory of Mrs. Boyd's father. The purpose of the endowment is not to popularize history, but rather to invite a few historians of distinction to reflect on the wider implications of their work, and to embody their reflexions in the lectures and in a book. It is hoped that the Wiles Lectures will bear fruit in two ways: on one hand by encouraging some younger historians to enter the difficult field of research into the history of ideas; and on the other hand, by broadening eventually the basis of the teaching of history in schools, so that more emphasis is put on supra-national than on national movements. The benefactress hopes to make a further gift to the Queen's University so that the purpose of the endowment may be continued beyond the experimental period of 7–10 years. In administering the endowment the Queen's University will be advised by a committee including its own professor of modern history, together with two scholars to be invited from other universities.

## Natural Gas in Britain

At a recent meeting of the Institution of Gas Engineers, Sir Harold Smith, chairman of the Gas Council, stated that an intensive, large-scale search for natural gas in Great Britain is to begin in the near future. The supply of good gas-making coal is decreasing and becoming more difficult to win, and therefore every possibility of developing methods of using coals normally considered unsuitable for carbonizing by orthodox means should be considered; further, the efficiency of existing carbonizing processes should be improved. But this is not enough, for the urgency in these matters is dictated by rapidly increasing cost of coal, and it is necessary that investigation into new supplies of gas from natural sources should be undertaken. In co-operation with the Anglo-Iranian Oil Co., Ltd., the Gas Council is proceeding with a scheme of exploration for natural gas in Britain estimated to last about five years. No rosy vista of commercial success can be envisaged, judged by past records, of which Heathfield, Sussex, is the classic example. None the less, a search sufficiently wide and deeply spread in Britain will at least settle once and for all this controversial problem of the occurrences of natural gas, and to this extent the scheme appears justified.

## Glass in Chemical Industry

Glass has for many years held pride of place in the field of laboratory apparatus, and in recent years its use is being extended to chemical industrial plant where the dimensions are on a very much larger scale. For the supply of laboratory glassware (mainly heat-resistant borosilicate glass) a well-known name is Quickfit and Quartz, Ltd., a firm which has built up a reputation in the manufacture of ground-glass standard interchangeable conical joints, whereby complicated pieces of apparatus can be built up from a relatively small number of standard components. The firm started before the Second World War at King's Norton, near Birmingham, and in 1946 transferred most of its work to Stone in Staffordshire (see *Nature*, 164, 907; 1949). Production at Stone is now in full swing.

The latest developments at Stone are mainly in the field of large pieces of glassware, and one of the most interesting processes that has recently been put into operation is the electric welding of large joints. Though this process is well known in the United States, where electricity is much used and the gas industry is small and, being based on natural gas, is not suitable for glass-working, the method has only been recently introduced into Great Britain. The method is at present only suitable for joints of a simple shape, such as putting on the neck of a flask, but the dimensions can be relatively big (for example, 20–30 cm. diameter). The two parts to be joined are mounted on a glass-working lathe, brought almost together and rotated between electrodes placed at opposite ends of a diameter. The electrodes are hollow and carry small gas-flames which heat up the glass and thereby reduce its electrical resistance from the order of megohms to thousands of ohms. The current is then switched on from a 120-kc./s. generator of 25 kVA. output. The current passes over the small gaps from the electrodes and flows through the glass, heating it uniformly through the body of the work but at the same time over an annular volume that is very narrow. The power factor is usually 0·5–0·8, and when the joint is made and the glass molten the current is about 3 amp. at about 10 kV., some 12 kW. being dissipated in the glass. The frequency of the generator is not critical; but at 120 kc./s. the voltage can only burn and not electrocute in the event of an accident to an operator. The main advantage of this method is the uniform heating through the glass and the small volume of heating as compared with large gas-flames, which heat only on the surface and over

a wide area, and for electric-welded joints the subsequent annealing process (which is very time-consuming) is much easier.

## Radiophysics Laboratory, Sydney

ONE of the Divisions of the Commonwealth Scientific and Industrial Research Organization of Australia is the Radiophysics Laboratory, situated in the grounds of the University of Sydney, and the chief of the Division is Dr. E. G. Bowen. The four main fields of research in the Laboratory are radio astronomy, cloud and rain physics, automatic computation and the development of radio aids to navigation, and in a very attractive and well-illustrated brochure, entitled "Research Activities of the Radiophysics Laboratory" (pp. 36. Melbourne: C.S.I.R.O., 1952), a brief account is given of the Laboratory's current work under these four separate headings. The section on radio-astronomy is mainly concerned with the study of radio noise from the sun and outer space. The design of a new solar radio-spectroscope, now under construction, which is to cover the frequency-range 40–240 Mc./s., and a 32-element interferometer, which will be used at decimetre wave-lengths for the location of sources of solar radio noise, are described. Investigations to determine the positions and characteristics of discrete sources of cosmic noise and the techniques involved are discussed, and an interesting study is outlined of the temperature and structure of the ionospheric *D*-layer by an application of a method first used in radio astronomy to measure the thermal emission from the solar corona. The study by micro-wave radar of rain formation and cloud-seeding experiments for rain-making are the main items in the rain and cloud physics section, and details of the binary type Mk. I digital computer which has now been in use for about a year are given in the section on automatic computation. In the final section, dealing with radio aids to navigation, are described two short navigational aids, the "Distance Measuring Equipment" for aircraft and the "Multiple Track Range" providing a number of flight tracks to and from an airport, and, in addition, a recently developed micro-wave direction-finding apparatus operating at a wave-length of 3·2 cm. The accounts of the work of each section are terminated by a detailed list of scientific papers published by its members during 1948–52.

## Imperial College of Science and Technology, London: Report for 1951–52

THE forty-fifth annual report of the Governing Body of the Imperial College of Science and Technology, London, covering the year ended July 31, 1952 (pp. 60; from the College, 1953), refers to the start being made on the new building for the Aeronautics Department, although the steel allocation was at that time being awaited. The creation of laboratories for mineral dressing in the Bessemer Laboratory was nearing completion and a small extension of the Department of Metallurgy was being made in the same building. The space available for expansion in the South Kensington area has been increased by purchase of the freehold of the property at 179 Queen's Gate, and an additional twenty-eight acres of land contiguous to the Field Station at Silwood Park, Sunninghill, have also been purchased. A series of lectures on general subjects for first-year undergraduate students was organized by the Dean of the City and Guilds College during 1951–52, and, with the London School of Economics and Political Science, joint postgraduate studies in technology, economics and administration have been arranged for the session 1952–53. As a further experiment in co-operation between academic staff and students, the College hours are being varied so as to leave two hours (12.30 p.m.–2.30 p.m.) on Tuesdays and Thursdays entirely free from organized College studies. On each of these days a joint committee of staff and students is arranging functions such as discussion talks by outside experts, concerts of chamber music and general entertainments organized by student societies. Besides the statement of accounts and details of teaching and administrative staff changes, appendixes to the report include a list of publications during 1951–52, arranged under departments.

## Dry Rot in Wood

A FIFTH edition of "Dry Rot in Wood", Bulletin No. 1 of the Forest Products Research Institute, by K. St. G. Cartwright and Dr. W. P. K. Findlay, has been issued under the auspices of the Department of Scientific and Industrial Research (pp. 36+8 plates. London: H.M.S.O., 1952; 2*s*. net). It is said that dry rot has become very much more prevalent during the past decade, though whether this is so has not been proved; nevertheless, there must be many people who are acquainted with the appearance of dry rot in the house in floor-boards and other woodwork. The attack is caused by *Merulius lacrymans*; moisture is necessary, and strands of the fungus can transport the moisture so that it can rot moderately dry timber once it has got a hold. Dry rot spreads easily. Like the white ant of the tropics in its search for timber, the fungus is said to be able to pass through brick or stone walls via the mortar. As to methods to combat it, the council of perfection is to have no damp spot anywhere in the house. "Leaky gutters, cracked pipes and so on should be repaired immediately. Cellars should be kept dry." Are all these precautions possible these days? There is often a considerable delay before repairs to leaking roofs, pipes, etc., can be effected, and, though it may be feasible to keep a small cellar dry, in country houses where the cellarage may be of fair size it would be very expensive to keep them heated throughout the winter; and, in the case of the wine cellar, the cherished wine would be ruined. Nevertheless, this edition of the bulletin has been thoroughly revised, and in houses of any size it should be regarded as indispensable. No simple practical remedial measure is apparently yet available.

## Metals in the Service of Man

IN the *Museums Journal* of May 1953, Mr. A. R. Hutchieson describes the modern treatment of the non-ferrous metals at the Royal Scottish Museum, Edinburgh. This has been arranged as a panorama of metals in the service of man. Beginning with a brief survey of their discovery and early uses, this is followed by an attractive introduction to the more technical exposition of modern extraction methods, processing and applications. Bold, colourful maps and diagrams are used, and by an imaginative selection of characteristic three-dimensional material the display has atmosphere and life. Aluminium, magnesium, nickel, copper, tin, lead and zinc have been dealt with, and the growing popularity of the new display with visitors indicates that the method of presentation has been successful.

## Deep-Sea Floor and the History of the Earth

A SYMPOSIUM on the "Deep-Sea Floor and the History of the Earth" has been arranged by the International Joint Commission on Oceanography of the International Council of Scientific Unions and will be held at the University of Liverpool during September 1–2 immediately preceding the meeting of the British Association. The International Union of Geodesy and Geophysics and the International Union of Biological Sciences are represented on this Commission, the constitution of which is as follows: *President*, J. D. H. Wiseman (Great Britain); *Secretary*, C. D. Ovey (Great Britain); *Members*, A. F. Bruun (Denmark), C. W. Correns (Germany), L. Fage (France), Ph. H. Kuenen (Holland), H. Pettersson (Sweden), R. Revelle (United States), Mary Sears (United States); *Advisory Councillors*, F. Bernard (Algeria), F. Koczy (Sweden), J. D. Nares (representing the International Hydrographic Bureau), J. Rouch (Monaco), H. U. Sverdrup (Norway), H. C. Urey (United States) and C. E. ZoBell (United States). The main object of the Commission is to stimulate international collaboration in fundamental research on deep-sea problems, through recent developments in electronics, physics, chemistry and biology, combined with technical advances in detailed surveying and sampling of the deep-sea floor, which have made possible a new level of scientific understanding of the deep sea.

## Merck Fellowships of the Canadian National Research Council

THREE post-doctorate research fellowships, endowed by Merck and Co., Ltd., have been awarded by the National Research Council, Ottawa. The awards, which total 11,000 dollars and travel allowances, with an extra 500 dollars to each institution concerned, to help pay for specialized equipment, have been made to the following for research as indicated: Dr. W. G. B. Casselman (Universities of British Columbia and Toronto), cellular physiology, at the University of Oxford, under Dr. J. R. Baker; Dr. G. D. Fasman (University of Alberta and the California Institute of Technology), alkaloids and nucleosides, at the Technische Hochschule, Zurich, under Prof. V. Prelog; Dr. B. A. Gingras (University of Montreal), reactions of free radicals in solution, at the University of Oxford, under Dr. W. A. Waters.

## Association of Applied Biologists

THE officers and council for 1953–54 of the Association of Applied Biologists is as follows: *President*, Prof. W. Brown; *Vice-Presidents*, Mr. R. W. Marsh and Prof. J. B. Cragg; *Honorary Treasurer*, Dr. H. F. Barnes; *Honorary General Secretary*, Dr. R. K. S. Wood (Imperial College of Science and Technology, London, S.W.7); *Honorary Programme Secretary*, Dr. L. Broadbent; *Honorary Editor of the Annals of Applied Biology*, Mr. R. W. Marsh; *Honorary Assistant Editor*, Dr. I. Thomas; *Council*, Dr. P. W. Brian, Dr. C. H. Cadman, Prof. J. B. Cragg, Dr. D. W. Fenwick, Dr. R. M. Greenslade, Dr. I. Isaac, Dr. W. F. Jepson, Dr. M. A. Keay, Dr. A. H. McIntosh, Mr. B. D. Moreton, Dr. I. W. Prentice and Dr. A. F. Posnette. The Association celebrates in 1954 the fiftieth anniversary of its founding, and to mark the occasion a series of special meetings will be held during September 13–17, 1954, to which a number of distinguished scientific workers from overseas will be invited. A jubilee fund for the expenses of this meeting was started in December 1952; further contributions to this fund should be addressed to the treasurer of the Association.

## University of London: Appointments

THE following appointments in the University of London have recently been announced: Dr. G. O. Jones, reader in experimental physics at Queen Mary College, to the University chair of physics tenable at that College; and Dr. W. B. Pennington, research Fellow at Jesus College, Cambridge, to the University readership in mathematics tenable at Westfield College. The title of reader in mathematics in the University has been conferred on Dr. C. A. Rogers in respect of the post held by him at University College, London.

## Announcements

SIR JOHN RUSSELL, formerly director of Rothamsted Experimental Station, has been elected a foreign member of the Finnish Academy of Science and Letters.

M. PHILIBERT GUINIER, director of the École des Eaux et Forêts, Nancy, and *correspondant* for the Section of Rural Economy of the Paris Academy of Sciences, has been elected a member of the Section in succession to the late Prof. L. Lapicque.

THE Institute of Fuel has awarded its Students' Medal and Prize for 1952 to B. H. Holland, of the Department of Coal Gas and Fuel Industries with Metallurgy, University of Leeds, for his paper on "The Structure and Stability of Flat Burner Flames".

DR. DAVID R. GODDARD, professor of botany in the University of Pennsylvania, has been elected editor-in-chief of *Plant Physiology*, the journal of the American Society of Plant Physiologists.

THE Committee of Privy Council for Agricultural Research and Nature Conservation has re-appointed Lord Rothschild as chairman of the Agricultural Research Council for a further term of five years. It has also approved the appointment of Prof. Stephen J. Watson as deputy chairman of the Council.

MR. R. C. WORSTER, who has been a member of the research staff of the British Hydromechanics Research Association since its formation, has been appointed deputy director of research in the Association.

THE following have been appointed lecturers in the University of Leeds: F. P. G. Whitaker (industrial administration in the Department of Economics), Dr. F. S. Trippet (organic chemistry), and T. J. Bowen (biochemistry).

THE Challenger Society is prepared to consider applications for small grants in aid of research in marine biology or oceanography at a recognized laboratory during the year June 1953–June 1954. Applications, accompanied by details of the proposed research, should reach the honorary secretary, Mr. N. B. Marshall, British Museum (Natural History), London, S.W.7, before the end of June.

ERRATUM. In the communication "Difference between the Density Distribution of Neutrons and Protons in Atomic Nuclei" (*Nature*, May 30, p. 979), paragraph 2, line 3, for "$1+b(r/r_0)^2$" read "$[1+b(r/r_0)^2]^2$".

# PHYSICS OF THE SOLID STATE

## PHYSICAL SOCIETY SPRING MEETING

THE spring meeting of the Physical Society was held in the Physics Department of the University of Leeds; the president of the Society, Prof. R. Whiddington, was in the chair. The meeting was devoted to several topics under the general heading of "Some Aspects of Solid State Physics" and was well attended, some hundred and eighty people being present.

Introducing the first session, "The Analysis of Magnetization Curves", Prof. E. C. Stoner (Leeds) related such curves with the general characteristics of ferromagnetics and the main processes by which change of magnetization may occur; these latter are changes in intrinsic magnetization, rotation of domain magnetization vectors and movement of domain boundaries. Much is now known of these processes individually, but the statements made about their relative contributions to a change along a magnetization curve of an ordinary polycrystalline material are little more than plausible guesses. By an 'analysis of magnetization curves' is understood a determination of the processes taking place; this can be achieved by a suitable combination of experimental measurements and theoretical reasoning. Measurements of the reversible susceptibility, together with the ordinary magnetization curve, enable the reversible and irreversible contributions to be separately determined. Investigation of the thermal changes accompanying adiabatic magnetization, on appropriate analysis, gives a quantitative indication of the contributions from the various elementary processes. The analysis can be made more nearly complete if that part of the thermal change associated with the reversible processes can be separately determined; this is possible by an indirect method recently developed. Further experimental work will be necessary before complete analyses are possible; but from partial analyses already made it appears that the main thermal effects are usually due to rotations and changes in intrinsic magnetization. The magnetic and thermal changes in moderate and, to a large extent, in low fields can be satisfactorily co-ordinated, but the detailed interpretation of the behaviour in high fields presents greater difficulties.

Prof. L. F. Bates (Nottingham) then gave a description of the method of measuring small temperature changes accompanying the magnetization of ferromagnetic rods in low and moderate fields. Examples were given of earlier measurements and their interpretation in terms of the Stoner and Rhodes theory in which the thermal changes due to the so-called magneto-caloric effect are subtracted from the observed changes and the differences used to calculate an important coefficient. Prof. Bates discussed the values of this coefficient for many metals and alloys, and showed some results for cobalt in which the reversible and irreversible thermal changes had been separated in a simple manner and the coefficient again calculated. Measurements on a 'Ferroxcube' rod were described, and these showed that the thermal changes accompanying magnetization were in this case almost entirely due to changes in intrinsic magnetization. Finally, he compared the results of high field measurements on 'Alnico' with the theory given by Rhodes of the heat changes in an idealized ferromagnetic of high coercivity.

An account was given by Dr. R. S. Tebble (Leeds) of the separation of the processes involved in the magnetization of a ferromagnetic at low fields from measurements on the reversible change in magnetization with temperature. The contributions of rotations of the magnetization vectors, and changes in intrinsic magnetization, have been estimated for annealed nickel, and it is probable that the effect of boundary movements can also be estimated. The agreement in high fields with the measurements of Bates and Davis was shown by Dr. Tebble to be good. He suggested that, if the appropriate measurements can be made on one specimen under carefully controlled conditions, it should be possible to extend this work to a separation of the reversible and irreversible components of the magneto-caloric effect.

Prof. W. Sucksmith (Sheffield) stated that the magneto-caloric effect in high fields probably constitutes the most useful and reliable method for tracing the variation of spontaneous magnetization with temperature and has only been applied fully to the case of nickel. A method of measuring the small rise of temperature with adequate accuracy has been developed. The experimental results for copper–nickel alloys have established a new feature in the non-linear relation between the rise of temperature and the square of the magnetization above the Curie temperature, while the tail of the spontaneous magnetization curve attributed to fluctuations by some writers is certainly not greater than for pure ferromagnetics; in the case of ferrites it becomes almost non-existent.

Mr. K. L. Hunt (Leeds) described a mathematical extension of the collective electron theory of ferromagnetism in which the energy associated with the magnetization is taken not simply as proportional to the second power of the magnetization but as dependent on both the second and fourth powers. A further adjustable parameter is thus introduced. A high degree of co-ordination may then be obtained between all the observed magnetic and thermal properties of nickel and of some nickel alloys. The change of magnetization with field in high fields is the single property for which a qualitative account only is possible. There are indications, however, that this change of magnetization is not entirely that of the intrinsic magnetization, even in high fields.

The next session, on "The Band Theory of Metals", was introduced by Prof. H. Jones (London), who gave a critical survey of the three main assumptions on which the theory is based. These are: (1) the Hartree–Fock self-consistent field method which implies that each electron is in a stationary state, the total wave function being written as a single Slater determinant of the one-electron functions; in consequence the total energy may be written as the sum of the one-electron energies together with an interaction term; (2) the interaction term is independent of the distribution of the electrons over the available states, implying that the electrons may be treated by Fermi–Dirac statistics; and (3) the one-electron functions may be expressed as the product of a space function and a spin function. In conclusion, Prof. Jones stressed the importance of calculations of basic characteristics of particular metals; these would enable the logical consequences

of the assumptions to be compared with experiment and the adequacy of the assumptions tested.

Dr. E. P. Wohlfarth (London) gave an account of an approximate treatment to determine the form of the total energy for a metal, the Bloch tight-binding approximation being used for the calculation. For infinite separation of the atoms, this approximation leads to the correct expression for the total energy when the spins of all the electrons are parallel; but when there is zero resultant spin moment, there is a large additional term in the energy expression. Dr. Wohlfarth suggested that, as a first approximation, this large correlation term could be treated as independent of interatomic distance when the dependence of the total energy on the number of electrons per atom and the magnetization could be estimated. He then related the results of this treatment to the analyses of Mr. K. L. Hunt. The applicability of Fermi–Dirac statistics to electrons in metals was also discussed, and he suggested that this provides a good approximation at least for those electrons which can be treated by means of the tight-binding approximation.

Experimental work on the transition elements, directed to the elucidation of their band structures, was then described by Dr. F. E. Hoare (Leeds). Starting with the simple picture of an incompletely filled *d*-band overlapped by an *s*-band, it is to be expected that alloying the appropriate neighbour of higher atomic number should fill the *d*-band at a particular concentration, the alloy then becoming diamagnetic. Alloying with a neighbour of lower atomic number should, on the other hand, create more holes in the band. The height of the band should vary in these alloying processes, and measurements of the electronic heats of the alloys will show the manner of this variation. The experimental results for the susceptibilities of palladium–silver and palladium–rhodium alloys were shown by Dr. Hoare, along with the electronic heats of palladium–silver, and the qualitative agreement with the simple band picture was discussed. The marked difference in behaviour of the electronic heat in the palladium–silver and nickel–copper systems was indicated. Preliminary results for the susceptibilities of the platinum–gold and platinum–iridium systems were shown, and it appears that these may be interpreted in the same general scheme as the former results.

Dr. P. Rhodes (London) discussed the dependence of the temperature variation of paramagnetic susceptibility and electronic specific heat on the form of the density of states relation. He showed how earlier treatments assuming simple band forms have led to the conclusion that the paramagnetic susceptibility is a monotonically decreasing function of temperature, whereas more recent experimental results for palladium and certain of its alloys with silver show that the susceptibility/temperature curves may exhibit maxima. Results for the low-temperature specific heat of the palladium–silver alloys indicate that the band form in palladium is not of the form assumed in the earlier treatments. When the treatment is developed using a band form appropriate to that derived from the experimental results, the calculated susceptibility/temperature curves do, in fact, exhibit maxima. A brief account was also given of some effects of band overlap and band closure.

A short description of the dependence of the steady (field independent) diamagnetic susceptibility of metals and alloys on their electronic structure was given by Mr. E. W. Elcock (Leeds), who indicated how the earlier treatments are inadequate to explain the complicated dependence of susceptibility on temperature and composition for alloys of polyvalent metals. He showed how, by a straightforward extension of these earlier treatments, it is possible to correlate effects of both temperature and alloying on the susceptibility. The alloys of bismuth with small concentrations of lead and tellurium were particularly considered, and the bearing of the treatment on a wider range of metals and alloys was indicated. Finally, Mr. Elcock suggested a possible interpretation of the curious oscillatory character of the temperature variation of the susceptibility of zinc in terms of the treatment developed.

In introducing the final session, on "Luminescence and Ferroelectricity", Dr. J. H. van Santen (Philips Research Laboratories, Eindhoven) reviewed the properties of pure and perfect non-metallic solids in terms of simple band theory. Impurities and imperfections modify these properties by introducing localized energy-levels. In elements such as germanium and silicon the type of semi-conductivity, *p* or *n*, depends on the valency of the impurity relative to that of the host. In alkali and silver halides the introduction of divalent ions leads to increased conductivity through the production of cation vacancies. In oxides, however, the impurity may also produce changes of valency in some of the host cations; for example, $(1-\delta)$ NiO with a small amount, $\delta/2$, of $Li_2O$ can be represented as

$$Li_\delta Ni^{2+}_{1-2\delta}\, Ni^{3+}_{\delta}\, O^{2-}$$

and has a *p*-type conductivity. Kröger has shown that gallium in zinc oxide can produce cation vacancies, change of valency of some zinc ions in a reducing atmosphere, leading to *n*-type conductivity or, under oxidizing conditions, to holes trapped near cation vacancies giving *p*-type conductivity. He considers that the blue luminescence of self-activated zinc sulphide is associated with the third kind of centre.

Dr. E. E. Schneider (King's College, Newcastle) gave an account of the mosaic structure of single crystals, citing evidence obtained from optical scattering that the size of the blocks is about 2000 A. He then surveyed the types of defects in crystals, with particular reference to Seitz jogs, which are considered to act as incipient vacancies. Discussing colour centres, he directed attention to the new colour-centre model of Kittel and Kahn in which an electron is regarded as being shared by the six negative ions surrounding the vacancy. This makes the *F*-centre similar to the *V*-centre, in which a positive hole is shared by six anions around a positive ion vacancy. Other *F*- and *V*-centres must exist and probably consist of simple aggregates of simple *F*- and *V*-centres and vacancies. Information on vacancies can be obtained from conduction measurements. Recent work by Cunnell on conductivity and polarization effects gives strong support for the mosaic idea and suggests that at low temperatures the positive ion vacancies are held at or near block boundaries. Coloration must include a mechanism which frees vacancies from boundaries. The build-up of *F*-centres under X-radiation, an initial steep portion with high efficiency followed by a less-steep portion leading to saturation, is attributed to an initial easy release of vacancies from boundaries followed by a less efficient release from Seitz jogs. Cunnell's work shows that a coloured crystal displays

a small conductivity with increasing temperature, an increase in the temperature-range of bleaching and the maintenance of this increased conductivity on cooling.

Mr. J. Ewles (Leeds) gave an account of investigations, recently completed at Leeds, into the optical and electrical properties of phosphors. He pointed out that luminescence is not a rare phenomenon in solids but is likely to accompany imperfections in crystals whether these are caused by impurities or by thermal treatment. It is, in fact, rarely absent in real crystals, being suppressed only with extraordinary purity and in the absence of thermal strains. It can be intensified by sudden quenching, and reduced or removed by annealing. Recent experiments carried out by Lee have led to a modification of the theory of the large centre first introduced by Ewles in 1930. The modified theory now takes into account the competition of structure centres provided by imperfections, and is in good agreement with experiment. Further, it permits the evaluation of the size of the centre. Mr. Ewles also gave a brief account of the remarkable optical and electrical properties of some new oxygen-activated alkali halide phosphors investigated by Barmby. These phosphors show sharply resolved luminescent bands which must be attributed to oxygen ions adsorbed on the halide. The luminescence is accompanied by very large increases in conductivity. Thermoelectric powers up to some two millivolts per degree indicate that the conduction is electronic, and an interpretation in terms of the effect of the adsorbed oxygen on the band levels of the halide crystals was given.

In the section on ferroelectricity, two papers were presented: the first, by Dr. L. E. Cross, on ferroelectricity in the perovskite type structures; and the second, on the theory of ferroelectrics, by Dr. A. F. Devonshire.

Dr. Cross (Leeds) directed attention to the importance of accurate measurement of electric hysteresis in the ferroelectric state. He described the method normally used for measuring the hysteresis, and examined the limitation imposed by the electric conduction through the ferroelectric. After a brief description of the perovskite structure, he listed the minerals which are of interest electrically and, from them, examined in more detail barium titanate, potassium niobate and sodium niobate. The sequence of symmetry changes which occurs on cooling barium titanate was described by Dr. Cross, and the electric domain structures occurring in the tetragonal room-temperature phase examined, new evidence being produced to confirm the existence of a system of anti-parallel domains within the individual twin unit. Hysteresis figures obtained on untwinned barium titanate crystals above the ferroelectric Curie temperature were shown, and these were compared with previous results in the United States. New measurements of electric hysteresis effects in potassium and sodium niobates were also reported. In the potassium salt, the results were shown to be in reasonable agreement with previous work. Preliminary results on sodium niobate, however, have revealed a linear dielectric up to field-strengths of 20 kV./cm., and clearly this is not a normal ferroelectric.

Dr. Devonshire (Bristol) said that he would consider only the theory of the single domain. This theory can be divided into two parts: first, the purely thermodynamic theory of the relations of the elastic, piezoelectric and dielectric constants to each other; and second, the relation of these to the atomic structure. It is important to carry out a thermodynamical analysis of experimental results, before devising a detailed atomic theory. This analysis shows that all the anomalies observed at the transition temperature are due to the fact that the dielectric stiffness coefficient tends to zero at this point; Dr. Devonshire also suggested that the first-order character of the transition in barium titanate is probably due to the interaction between strain and polarization. The smallness of the dielectric stiffness coefficient is due largely to electrostatic interaction between the different parts of the polarized medium; this is in contrast with ferromagnetic materials, for which magnetostatic interaction is of small importance. The temperature variation is due to the higher entropy of the unpolarized state. The existence of a lower transition in Rochelle salt is probably due to the existence of a stable anti-parallel arrangement of dipoles below this temperature.

The meeting provided a welcome opportunity for an exchange of views among those working in related fields, and full advantage was taken of this in a number of extended informal discussions.

F. E. Hoare

## OXIDATION OF OILS AND FATS

A SYMPOSIUM on "Oxidation" was held by the Oils and Fats Group of the Society of Chemical Industry in the Low Temperature Research Station, Cambridge, on April 24. Prof. T. P. Hilditch, chairman of the Group, presided and welcomed some hundred-odd members and visitors. The programme was divided, after an introductory address, into two sessions of two papers each, one dealing mainly with the oxidative deterioration of fats and the other with the autoxidation of unsaturated fatty acids and esters and other topics related to drying oils and paints. Although the approach to, and aim of, this aspect of the problem are different, the chemical changes which take place have the same common basis, and for this reason the discussion on all the papers was taken together.

Prof. C. E. H. Bawn, in his introductory address, reviewed the fundamental ideas on the mechanism and chemistry of varied classes of organic molecules; for example, hydrocarbons (saturated, unsaturated, aromatic and hydro-aromatic), aldehydes and ketones, etc., which readily undergo autoxidation in the liquid or solution phase at relatively low temperatures. The radical chain theory of these processes has in recent years come to be widely accepted, and it is agreed that the initiation of the reaction requires the production of a free radical either by direct oxygen attack, photochemically or by an added agent. The reaction chain has been established to be of the following type:

$$\begin{aligned} \text{Initiation} &\rightarrow \text{free radical } R. \\ R + O_2 &\rightarrow RO_2 \\ RO_2 + RH &\rightarrow ROOH + R \\ R + R &\rightarrow \\ R + RO_2 &\rightarrow \text{inert products} \\ RO_2 + RO_2 &\rightarrow \end{aligned}$$

where $RH$ = hydrocarbon, aldehydes, etc.

The initially formed hydroperoxide ($ROOH$) is of varying stability, and at higher temperatures readily undergoes further decomposition. This decomposition is also a chain mechanism, and many examples conform to the following type:

$$R\text{OOH} \rightarrow R\text{O} + \text{OH} \text{ or } 2R\text{OOH} \rightarrow R\text{O}_2 + R\text{O} + \text{H}_2\text{O}$$
$$R\text{O} + R'\text{H} \rightarrow R\text{OH} + R'$$
$$R' + R\text{OOH} \rightarrow R'\text{OH} + R\text{O}.$$
$$2R' \rightarrow \left.\right|$$
$$R' + R\text{O} \rightarrow \left.\right| \text{inactive products}$$
$$2R\text{O} \rightarrow \left.\right|$$

where $R'$H may be parent molecule $R$H, solvent or added substrate. These secondary chain reactions, together with the direct thermal decomposition of the peroxide to saturated molecules and the decomposition of the radicals $R$O and $R\text{O}_2$, give rise to the variety of products—aldehydes, ketones, alcohols, acids and esters—which usually appear when the oxidation is carried to any considerable extent. It is these reactions, to which all unsaturated organic compounds in particular are susceptible, which have important practical consequences, and, as will be seen from the papers discussed, they are responsible for the development of the rancidity of fats, the gelation of drying oils and also the deterioration of rubber and other high polymers.

It is well known that the salts of the heavy metals are good catalysts for autoxidation reactions, and these reactions are of great technical importance particularly in the field of drying oils and 'controlled' oxidation to form selective intermediates, such as the oxidation of aldehydes to acid anhydrides, *cyclo*hexanol to adipic acid and *iso*propyl benzene to its hydroperoxide.

The point of view was expressed that these catalysts function essentially in the ionic form and that their activity resides in their ability to undergo electron-transfer reactions giving rise to free radicals: for example,

$$\text{Co}^{++} + R\text{OOH} \rightarrow \text{Co}^{+++} + R\text{O} + \text{OH}^-$$
$$\text{Co}^{+++} + R\text{OOH} \rightarrow \text{Co}^{++} + R\text{O}_2 + \text{H}^+.$$

Prof. Bawn also referred to the profound effects of oxygen in polymerization mechanisms in which it may initiate and inhibit polymerization, and induce degradation, branching or cross-linking of polymer molecules according to conditions and environment.

In the opening paper of the first session, Dr. C. H. Lea reviewed some recent studies of the oxidative deterioration of edible lipoids. He said that the degradation products of the primarily formed hydroperoxide, particularly αβ unsaturated aldehydes and ketones, are largely responsible for the unpleasant odour and flavour of oxidized fats. The relatively rapid autoxidation of poly-unsaturated acids compared with oleic acid emphasizes the deleterious effect of even small proportions of these acids in food fats. These substances not only increase the susceptibility of the whole fat to oxidation, but also the presence of acids containing three or more double-bonds seems to be the cause of the development of the characteristic 'off' flavour, usually described as 'reverted'. The actual mechanism by which these flavours are produced is not fully understood, but the consensus of opinion appears to be that they result from the oxidation of linolenic and more highly unsaturated fatty acids to a substance of unsaturated aldehydic and ketonic structure. Traces of copper and iron favour the development of flavour in fats, and quantities as low as a few parts per million produce appreciable effects in refined oils. In this respect the presence of chelating agents which inactivate trace metals has proved to be of considerable value in improving stability. The composition of animal fat, which is influenced by such factors as diet and rate of growth, affect the susceptibility to the development of oxidative rancidity. Dr. Lea discussed evidence from recent literature that peroxidized fat may be present in the tissues of still living animals which have been subjected to ionizing radiation. This problem is being mainly studied in the United States, and it has been observed that radiation initiates oxidative reactions in many foodstuffs with the consequent development of undesirable flavours. Dr. Lea also referred to the effect of enzymatic catalysts—the lipoxidases—which accelerate the peroxidation of unsaturated fats and fatty acids. These enzymes are very specific in their action towards different types of unsaturated groupings. In the United States much work has been done on antioxidants, and these are used extensively in fats and fat-containing materials. In Britain the whole question of the addition of antioxidants to food, like that of other non-nutrient chemicals, is still under consideration.

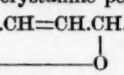
In the second paper Dr. Banks described some observations on the autoxidation of linoleic acid. He concluded that the product is a mixture of peroxides, which cannot readily be separated; but after reduction and separation by partition between petrol ether and aqueous methanol two types of linoleic esters (hydroxy acids) are isolated. Investigations of the autoxidation of methyl linoleate in the presence of lauric and palmitic acids at 35° and 55° C. show that esterification does not occur at these temperatures, and this suggests that esters isolated are formed during reduction of the peroxides.

A review of recent work on the oxidation of monoethenoid fatty acids and their higher esters catalysed by metallic soaps (uranium, thorium, vanadium, etc.) was presented by Dr. Skellon. This work confirms that the primary product is a hydroperoxide which decomposes to give either epoxy, aldehydic, dehydroxy or keto-hydroxy derivatives. Oleic acid forms hydroperoxide only slowly at low temperatures, but at 85° and 120° C. this process is rapid, and the peroxide concentration passes through a well-defined maximum. Dihydroxy stearic acid, 10-hydroxy stearic acid, and small amounts of scission products have been isolated from the breakdown products of the hydroperoxide. Results were also given for the autoxidation of the *trans* isomer, ethyl, propyl and butyl esters of oleic acid, petroselenic acid, methyl recinoleate, and erucic and brassidic acids.

The drying of oil films and the manufacture of blown oils and linoleum gels are processes which depend on the formation of polymers by autoxidation. The results that have recently been obtained from extensive studies on these problems at the Paint Research Station were summarized by Dr. L. A. O'Neill. Evidence was presented in support of the view that one of the polymer-forming reactions in the autoxidation of non-conjugated drying oils results from the metallic salt-catalysed decomposition of the initially formed hydroperoxide. The main products obtained from the decomposition of the hydroperoxides of methyl linoleate and methyl linolenate are —C—C bonded dimers which retain the full unsaturation of the original esters. Some unsaturation is lost in the process, and conjugated esters are formed by double-bond shift.

The products from the autoxidation of the conjugated drying oil—methyl elæostearate—are mainly monomeric peroxides (one of which has been isolated in the crystalline form) together with small amounts of polymeric peroxides which do not seem to be

bonded by peroxide linkages. A tentative formula was proposed for the crystalline peroxide as



Dr. O'Neill also described the results of direct studies of the autoxidation of drying oils in film form. Thus linseed oil takes up eight atoms of oxygen per molecule. Some of this oxygen is lost as volatile products, and only five atoms are retained after fourteen days. The volatiles include water, carbon dioxide, aldehydes and acid (particularly formic acid). Little change occurs in the film after a few days, and it seems necessary to postulate scission of the oxidation polymer in order to explain this high oxygen take-up. C. E. H. BAWN

## SCIENCE AND GOVERNMENT

IN his address, "Science and Government", to the American Chemical Society at its meeting in Los Angeles on March 16, Dr. L. A. DuBridge suggested that there are three points of contact between government and science. First, the nature, form and operation of the government determine the political, economic and intellectual climate of a nation, and whether the resulting climate is favourable to science or not may be accidental. If science is to flourish, however, that climate must provide for intellectual freedom, progressive change and the recognition and encouragement of intellectual pursuits. Secondly, science and its technological applications produce changes in the way men live, requiring corresponding changes in the operations, and possibly even in the forms of government. Advances in technology are a major source of advances in human welfare. Thirdly, science and government come together most directly and intimately when science affects matters such as national defence, agriculture, industry, transport, navigation, conservation of natural resources, flood control and the weather, which are prime functions of government.

Following this, Dr. DuBridge reviewed the gradual growth in the United States of government interest in science, from the establishment of the U.S. Coast Survey in 1807 and the creation of the Smithsonian Institution in 1846, until in 1952 Federal Government expenditure on research and development in science and technology was about 1,250 million dollars, or more than 40 per cent of the country's total expenditure on research and development. More significant, however, than this increase in Federal expenditure on research, in Dr. DuBridge's opinion, is the increase in non-Federal research expenditure, from 143 million dollars in 1930 to 1,740 millions in 1952. Pointing out that it is almost impossible to distinguish rigidly between expenditure on military and non-military purposes, or even between research and development, Dr. DuBridge classified government activities according to five different management techniques commonly used: government agencies under civilian management; government agencies under military management; government-owned institutions managed privately under contract; contracts for research or development services; and contracts or grants in support of research, usually to colleges or universities.

Dr. DuBridge does not believe that the United States Government is at present getting full value from its vast expenditure on research and development. He thinks that expenditure under the fifth category—research grants—is the most fruitful and valuable. In 1952 this, however, only amounted to about 71 million dollars; and he urged that this should be substantially increased. He is concerned also that 87 per cent of these funds come from the Atomic Energy Commission and the Department of Defence, whereas, in place of the 15 million dollars requested for basic research by the National Science Foundation, the Foundation has only received 3·25 millions in 1952 and 4·75 millions this year. As regards contracts for research services, Dr. DuBridge repeated the warning frequently given by others, that universities and colleges should be chary of accepting too heavy a load of such sponsored research lest their programmes of basic research be endangered.

The opinion was expressed by Dr. DuBridge that the most successful device for development of new ideas, equipment or techniques for the military services is that of government research centres under private management, such as the Los Alamos Scientific Laboratory operated for the Atomic Energy Commission by the University of California. He believes it desirable that any new research facilities—and as many existing ones as possible—should come under the private management contracts rather than military direction. Apart from proving grounds and acceptance or inspection centres, research centres for new military weapons would be more efficient under civilian direction. It is necessary, moreover, not only to give more attention to planning weapon development expenditure but also to consider problems of grand national strategy against the background of recent scientific and technical developments. For this reason, he suggested the appointment of an outstanding scientist or engineer as scientific adviser to the Defence Department, who might also serve as chairman of the Research and Development Board. The chairman of the Atomic Energy Commission should, in his opinion, be a member of the National Security Council, and that Council should be provided with a science advisory council with a full-time chairman.

## U.S. NATIONAL SCIENCE FOUNDATION

### RESEARCH GRANTS

DURING the year ended June 30, 1952*, the National Science Foundation made ninety-six grants totalling 1,073,975 dollars for the support of basic research in the biological, medical, mathematical, physical and engineering sciences at fifty-nine institutions in the United States. Research proposals totalling 13·3 million dollars were received, of which 38 per cent were declined, withdrawn or represented reductions in budgets of approved proposals, and 54 per cent are pending. New proposals submitted in 1953 will exceed the 1952 figure, but the limited Foundation funds for research have discouraged many competent investigators from submitting proposals. Those submitted to date have been marked to an unusual extent by originality in

* Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Govt. Print. Office, 1953.) 30 cents.

concept, boldness in design and a desire on the part of scientists to explore important but relatively neglected fields. While there appear to be large untapped resources for research in the colleges, universities and other non-profit institutions in the United States, the Foundation has discovered many areas of great scientific interest needing additional support, and nearly 75 per cent of its financial grants went to institutions previously participating least in Federal research support. About 52 per cent of these financial grants was spent on direct assistance to graduate students and other research assistants. Of the sixty-eight grants, totalling 762,675 dollars, for biological and medical research, molecular biology claimed the most, particularly the physical chemistry of proteins and related substances found in living tissues. In this programme the work on photosynthesis is of special interest, and the Foundation, along with other agencies, is supporting photobiological research in various institutions. Much support has also been given to research on regulatory biology and to systematic biology.

In the physical sciences, 29 grants, totalling 311,300 dollars, were awarded, and the report stresses the Foundation's obligation to support integrated attacks upon borderline and inter-disciplinary problems. In the engineering sciences, the Foundation's programme places its emphasis on such fields as fluid mechanics, strength of materials, heat transfer, corrosion, and thermodynamics, which are common to several branches of engineering, and it is also encouraging research designed to fill gaps in the basic information at present available to the engineer. Special attention is being given to projects bearing on the extension of the use of strategic materials, their replacement with new, hitherto unknown, materials and the better understanding of the conversion of energy. In the terrestrial sciences, the Foundation's programme is expected to embrace eventually more or less equally studies of the atmosphere, the waters, the surface, and the interior of the earth and their interrelations, and especially microphysical processes basic to the discovery and understanding of geophysical and geochemical principles.

Of the 624 graduate fellowships in the sciences awarded in April 1952 for the academic year 1952–53, 55 were made to post-doctoral applicants. Of the remainder, 169 went to those entering their first year of graduate study, 170 to second-year graduates and the remaining 230 to advanced pre-doctoral students. Biological sciences claimed 158 fellowships, chemistry 140, physics 137, engineering 75, mathematics 62, the terrestrial sciences 36, agriculture 7, astronomy 6 and anthropology 3. While this fellowship programme immediately affects the shortage of scientific men, the Foundation recognizes that the eventual correction of that shortage requires a long-range attack on defects in the educational, social and economic structure of the United States. At present the annual output of trained men of science in the United States is ten per cent or more below demand, and the 3,600 new doctorates in the sciences each year—rather less than 10 per cent of the output of graduates—is too low to meet the expanded current needs of technology; and the situation is expected to become more critical. Meanwhile, the operation of the present National Scientific Register, for which the Foundation assumed financial responsibility after the passage of the National Science Foundation Act of 1950, was to be discontinued after December 31, 1952, when the Register should have completed the initial registration and analysis of data on scientists trained in chemistry, chemical engineering, physics, psychology, agricultural and biological sciences, geosciences, and veterinary medicine. The Foundation has established an office to assist the professional scientific societies in compiling information on scientific workers in various fields on a uniform basis.

Its survey of publications has led the Foundation to believe that no continuing Federal support of scientific periodicals is desirable at present, though in critical cases temporary emergency support may be appropriate. The development of improved methods for compiling scientific information and for its rapid handling, economical storage, and efficient distribution is being followed, and the Foundation is also giving attention to the international exchange of scientific literature, particularly the availability of foreign scientific literature in the United States. A complete survey is being made of the present pattern of distribution and processing of Russian scientific literature in the United States.

## UGANDA FOREST DEPARTMENT

### ANNUAL REPORT FOR 1951

THE annual report of the Forest Department, Uganda, for 1951* gives full evidence that the Government of Uganda is intent on putting into force its declared forest policy. This is noteworthy, since during the present century (a forest policy was first laid down in India during the past century) such a policy has been enunciated for several forestry departments of the British Commonwealth and remained a dead letter. The general forest policy in Uganda comprises the maintenance of an adequate forest estate for protective and productive purposes, the management of the estate to fulfil those objects, the teaching to the people of the value of forests, and the encouragement of the practice of sound forestry by local authorities and private enterprise. To carry out these objects the forest officer requires the full support of the civil administration in the district and of the headquarters Government presided over by the Governor. That the Uganda Forest Department has the full support of the civil administration is evidenced by its present position in professional matters and the great strides that have been made in recent years.

To a considerable extent this progress must have been aided by the statement on "Land Policy of the Protectorate Government in Uganda", issued by the Government in 1950. This reaffirms that rural lands are being held in trust for the use and benefit of the African population; it further goes on to state that, while the Protectorate Government retains the forest rights, the Governor may, at his discretion and regard being had to the circumstances of each case, make an *ex gratia* payment to the African local government concerned of a portion of the income derived from Crown forest rights.

That good professional administration is possible under the present régime is shown by the progress made in the enumeration of the growing stock in the forests, the preparation of working plans and the striking sylvicultural investigations being undertaken by the research staff, the plantation work being

* Uganda Protectorate. Annual Report of the Forest Department for the Year ended 31st December 1951. Pp. iv+38. (Entebbe: Government Printer, 1952.) 2s.

carried out for both the people and for industrial use such as tobacco, etc. The great trouble being experienced is the want of labour, and some provisions of the working plans have had to be modified for this reason. Arrangements have been made, through longer leases of forests being granted, for improvement in milling and extraction. An important part of the work is connected with the conservation and protection of forests, especially in catchment areas of rivers and streams, and on the maintenance of this work so much of the future progress and prosperity of the people will depend.

The report was written by Mr. C. Swabey, the recently appointed conservator in Uganda, and Mr. Swabey has written a letter to me in which he takes exception to certain remarks I have made in the reviews of Uganda forest reports for 1949 and 1950 (see *Nature*, **168**, 507 (1950) and **169**, 1005 (1952)). In the 1949 report it was stated that local African governments were being encouraged to take over forestry work in areas where there was sufficient forest estates and that the district forest officer would act less and less in his official and trained capacity in those forests. In the report for 1950 it was stated that during the year the proposed devolution of the management of local forest areas was further developed. Past experience has shown time and again that, in the ultimate resort, the forest authority has no power to enforce regulations made by the civil authority. When the people become dissatisfied with the restrictions inevitable in good forest management, they commence to ignore them, with the result that friction arises which may easily go further. To avoid this in the past, the methods of forest management have had to be modified, at the instance of the civil authority. Improvements in the forest area and its usefulness may then disappear in a very short time. This will be the final test for a Department which, as the present report demonstrates, is making magnificent progress with the full support of the Governor and civil administration behind it.

E. P. Stebbing

## STRYCHNINE AS A DEPRESSANT OF PRIMARY INHIBITION

By K. Bradley and Prof. J. C. Eccles, F.R.S.
Departments of Physiology, University of Otago, Dunedin, New Zealand, and the Australian National University, Canberra

THERE have been many investigations on the convulsive action of strychnine[1–7]; but it has hitherto not been possible to determine the essential nature of the action. For example, it would still be possible to hold that strychnine transforms inhibitory synaptic action into excitatory action, or alternatively that it merely intensifies excitatory synaptic action. No decisive experimental test has been possible because the testing reflexes have always been evoked by afferent volleys composed of admixtures of excitatory and inhibitory impulses. Even a pure group I afferent volley from a muscle nerve will exert, by virtue of its group I*a* and I*b* components respectively, excitatory and inhibitory actions on homonymous motoneurones and inhibitory and excitatory actions on antagonist motoneurones[8–10]. Perhaps the only significant evidence is that in subconvulsive doses strychnine has little or no effect on

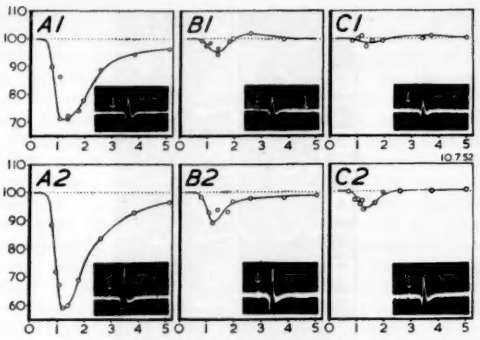



Fig. 1. Height of test reflex spike resulting from a single maximal afferent volley on biceps-semitendinosus nerve. Recorded from $S_1$ ventral root, and preceded at various intervals by an inhibitory volley in quadriceps nerve. Ordinates, heights of test reflexes as percentages of control height. Each point is mean of twenty observations as determined by method of superimposed tracings. Abscissæ: interval in milliseconds between inhibitory and test afferent volleys as recorded by an electrode in contact with the $L_6$ dorsal root close to its entry into the spinal cord

the monosynaptic reflex discharge, while there is a great increase in polysynaptic discharges[1,2,5,6]. Since the monosynaptic discharge evoked by group I*a* impulses would occur before the complicating disynaptic inhibitory effect of the group I*b* impulses[8], this evidence indicates that strychnine does not appreciably intensify the monosynaptic excitatory action of group I*a* impulses.

The present communication is principally concerned with the effect produced by strychnine on the direct inhibitory action which group I*a* impulses in the quadriceps nerve exert on the antagonist biceps-semitendinosus motoneurones. The initial requirement of this investigation was to distinguish between group I*a* and I*b* impulses in the afferent volley. In some, but not all, low spinal cat preparations under nembutal anæsthesia, a group I afferent volley set up in the quadriceps or biceps-semitendinosus nerves gives a double spike potential when it is recorded triphasically by a surface lead from a dorsal root as it is about to enter the spinal cord (cf. Fig. 3 and the lowest two inset records of Fig. 2). The second spike has a higher threshold than the first, and often it is possible to have the first spike more than half maximal with no detectable contamination by the second, as is shown in Fig. 3, in which the first stimulus was varied in strength from just above group I*a* threshold to about three times this strength, while the second stimulus was about three times

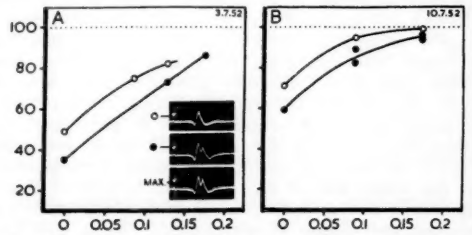



Fig. 2. Plots of test reflexes taken at the interval after the inhibitory afferent volley giving maximal effect (cf. Fig. 1), and expressed as percentages of control test reflexes (ordinates) against dosage of strychnine (mgm./kgm. body-weight: abscissæ) in two experiments. In each experiment two sizes of inhibitory volley have been used. In graph *A*, the smaller inhibitory volley (open circles) contained little, and the larger (filled circles) considerable group I*b* contribution (see in inset dorsal root spikes for corresponding symbols). In graph *B* the two inhibitory volleys are those used in Fig. 1

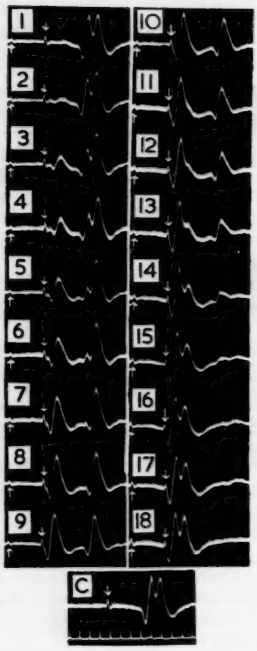



Fig. 3. Triphasic records of two group I afferent volleys from quadriceps nerve and recorded by a surface electrode on $L_4$ dorsal root close to its entry into the cord. Each record is formed by superposition of twenty faint traces in order to minimize random noise. *C* gives control response to second stimulus alone with two spikes (I*a* and I*b*) 0·17 m.sec. apart

threshold and 0·68 m.sec. later, so that it failed to excite any fibres that were excited and made refractory by the first. In records 7 and 8 there is virtually no group I*a* spike in the second response, that is, the first stimulus excited almost all I*a* fibres and yet virtually no I*b* fibres. Appreciable I*b* excitation only occurs from record 9 onwards. In this way it has been shown that the afferent impulses represented by the earlier spike cause monosynaptic excitation of homonymous and inhibition of antagonist motoneurones, whereas impulses of the second spike have no detectable monosynaptic action, that is, the first and second spikes are identifiable as group I*a* and I*b* respectively.

Fig. 1 (*A*1) shows the time course of the inhibitory effect of a group of I*a* afferent volley with no significant contamination by group I*b*. A subconvulsive dose of strychnine (0·09 mgm./kgm.) diminishes and shortens the inhibition (*B*1) and a further dose (0·08 mgm./kgm.) virtually abolishes the inhibition (*C*1). In *A*2, *B*2, *C*2 the quadriceps afferent volley is larger but still contains few, if any, fibres of group I*b*. The control inhibitory curve resembles that of *A*1, but the inhibition is larger, corresponding to the larger size of the group I*a* volley. There is likewise a corresponding diminution of the inhibition by the two doses of strychnine. Note that this diminution is much larger than the relatively small decrease in the dorsal root volley.

The effect of strychnine in diminishing the direct inhibitory action of group I*a* afferent impulses has been observed in all our experiments (eleven in all). Typical dose-response curves are shown in Fig. 2. Strychnine has also been observed to depress the polysynaptic inhibitory effect of cutaneous afferent volleys. Thus strychnine would seem to have a specific depressant action on synaptic inhibition, for this action is observed with doses which have no significant action on synaptic excitation as tested by the monosynaptic reflex.

Two alternative explanations of this specific action may be suggested: that strychnine acts competitively to reduce the bonding of an inhibitory transmitter substance with the subsynaptic membrane, much as curare is believed to depress the action of acetylcholine at neuro-muscular junctions and ganglionic synapses; or that strychnine interferes with the inhibitory action further downstream, for example, by depressing the hyperpolarizing action of the postulated inhibitory transmitter substance[11,12].

Finally, this specific effect of strychnine gives rise to the question: How far is it possible to explain its convulsive activity solely by its depressant action on inhibition? At least it is the simplest initial postulate that depression of the inhibitory synaptic action on interneurones causes the great apparent increase in polysynaptic excitatory action[1,5] which is so characteristic a feature of the strychninized nervous system. [Sept. 24.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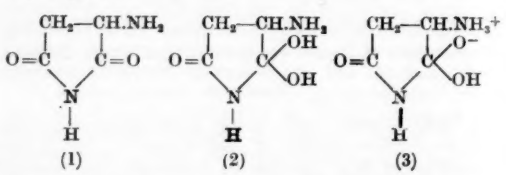
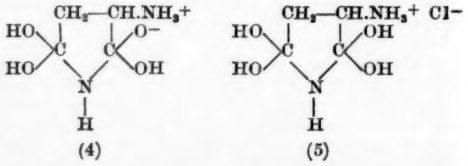
## STRUCTURE OF ASPARAGINE

STEWARD AND THOMPSON have recently discussed the properties of glutamine and asparagine and proposed a new cyclic structure for asparagine[1].




In the accompanying formulæ, (1) represents the (hypothetical) parent structure used by Steward and Thompson, amino-succinimide. (2) and (3) represent the uncharged and zwitterionic forms of anhydrous asparagine respectively, whereas (4) is their formulation of the monohydrate. The authors apparently

consider asparagine in solution as a tautomeric system in which the cyclic form is in equilibrium with the conventional straight chain, but with the former very much preponderating.

It seems to us that there are many difficulties associated with this view. Since Steward and Thompson regard the straight-chain formulation as correct for glutamine, their arguments based on different chemical properties of asparagine and glutamine lose force in view of the postulated tautomerism of asparagine. An equilibrium of this type could explain additional properties of asparagine and slower rates of reaction through the straight-chain form compared with non-tautomeric amides. It could not, however, explain the complete failure of nitrous acid to react with the asparagine amide group, since other reactions of the straight-chain form (for example, with acid, alkali or ninhydrin) take place at a measurable rate. Furthermore, many of the arguments advanced by Steward and Thompson in favour of a cyclic structure for asparagine apply with equal force to *iso*-asparagine, which also exists in the form of a hydrate. However, the analogous structure for *iso*-asparagine hydrochloride would be formula (5), which also represents asparagine hydrochloride. The two substances should therefore be interconvertible in solution, whereas they are, in fact, quite distinct chemically.

Our view is that the straight-chain formulation, possibly modified by hydrogen bonding, adequately represents the structure of asparagine, and that most of the differences in behaviour between asparagine and glutamine represent anomalies in the behaviour of glutamine rather than asparagine. Thus it is definitely glutamine which is anomalous in its behaviour towards nitrous acid, since its amide group reacts very readily. Other amide groups do not normally react with nitrous acid under the conditions of the van Slyke estimation, but require prolonged reaction in the presence of mineral acid[2]. Moreover, in proteins where, as Steward and Thompson admit, only the straight-chain formulation is possible for the combined asparagine, it is known that amide groups react with nitrous acid only very slowly if at all, even in the presence of mineral acid[3]. In its ease of hydrolysis to liberate ammonia, glutamine has been described as a "unique amide"[4], whereas investigations we have just completed show that the rate of hydrolysis of asparagine by acids is similar to that of acetamide under comparable conditions and gives normal values for the energy and entropy of activation. It should also be noted that substitution of the amino group of glutamine, as, for example, in leucylglutamine, slows down the rate of hydrolysis of the amide group to a rate of the same order as that of asparagine[5] and also causes the amide group to become unreactive towards nitrous acid[6]. On the other hand, it is of interest that N-methylation of the amide group of glutamine does not affect the reaction with nitrous acid[7], and in glutathione, a γ-glutamyl peptide, this reagent also reacts with some of the peptide nitrogen[8].

More conclusive evidence against the cyclic structure of asparagine has emerged from our kinetic studies on the rate of hydrolysis of the amide group of asparagine peptides. Inspection of Steward and Thompson's cyclic structure shows that it cannot be maintained for peptides of the type asparaginylglycine, whereas glycyl- or leucyl-asparagine could still possess a cyclic structure. If the hypothesis of ring structure is correct, therefore, one could expect similarities of behaviour between the amide groups of asparagine and peptides of the glycylasparagine type, but contrasting behaviour from peptides of the asparaginylglycine type. Kinetic data on the acid hydrolysis of the amide group show the converse of this relationship. The hydrolysis of the amide group of L-asparagine and L-asparaginylglycine by acid are both second-order reactions, being first order in amide and hydrogen ion. Moreover, the rates of both reactions are similar, and derived thermodynamic data are reasonably comparable for both compounds. Glycyl- and L-leucyl-L-asparagine, however, both show behaviour contrasting sharply with that of asparagine on acid hydrolysis. For these peptides the reaction is first order only in the molecular species of the type glycylasparagine hydrochloride, and the rate of hydrolysis is independent of hydrogen ion concentration at *p*H values where this ionic form preponderates. Under comparable conditions the amide groups of these peptides hydrolyse much more rapidly than those of asparagine and asparaginylglycine, the greater rate being due to a more positive entropy of activation.

Full data on these kinetic experiments will be published shortly.

January 6. Since submitting this communication, we have read the letter by Katz *et al.*[9] on the three-dimensional X-ray analysis of the structure of glycyl-L-asparagine crystals. This provides additional direct evidence against the cyclic structure proposed for asparagine by Steward and Thompson.

S. J. Leach
H. Lindley

Biochemistry Unit,
Wool Textile Research Laboratory,
Commonwealth Scientific and
Industrial Research Organization,
Melbourne.
Jan. 5.

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Through the courtesy of Drs. Leach and Lindley, we have seen their communication on the structure of asparagine, prior to its publication. This and numerous other comments that we have received testify to the interest which our article[1] aroused. In that sense, part of our purpose was achieved, since we wished to direct attention to the problem. Other recent and relevant communications are those of Katz, Pasternak and Corey[2] and of Cochran and Penfold[3], and a paper by Davies and Evans sent to us prior to its submission to the Chemical Society in London.

These communications may be summarized as follows.

(1) In the form of its peptides and even in certain cases where asparagine occupies a terminal position, the evidence of crystal structure is consistent with the combined asparagine existing in the conventional open-chain form[2].

(2) Cochran and Penfold[3] have published their evidence, referred to by us as communicated privately

from Dr. Pepinski, which shows crystalline glutamine has the open-chain form.

(3) Davies and Evans[4] have re-examined the infra-red absorption spectra of asparagine and glutamine and, as a result of this, they prefer the alternative structure for asparagine which was suggested to us by Dr. M. L. Huggins.

(4) Leach and Lindley refer again to the general problem, and from evidence derived from the rates of hydrolysis of peptides they now question whether there is any major structural difference between asparaginyl-glycine and glycyl-asparagine. Since the latter could contain asparagine in the ring form, this is interpreted by Leach and Lindley to mean that the ring form of asparagine does not exist.

(5) Leach and Lindley also state that their evidence indicates that asparagine is decomposed by acid at a rate more comparable to that of acetamide than to that of glutamine.

It should be recognized that we were concerned to explain certain stated differences in both chemical and physiological properties of *free* asparagine and glutamine in solution. It is of interest, as indeed we suggested, if these differences extend to situations in which the asparagine and glutamine are present in the form of their compounds. On the other hand, the fact that the compounds of glutamine and asparagine, or even their crystals, do not exist in the stipulated form does not necessarily disprove the postulated structure for free asparagine. We are still left with the problem of explaining the marked differences between these two compounds as they occur in the *free* state and in solution.

Leach and Lindley refer to the fact that *iso*-asparagine exists and that this compound also might occur in a cyclic form. Of this we were well aware; but since we had no data on which to base comparison of the relevant properties of *iso*-asparagine and asparagine, it did not seem helpful to refer to this interesting compound, which does not apparently occur in Nature. So far as we can tell, Leach and Lindley have not compared *iso*-asparagine with asparagine and/or glutamine. Until this is done, any speculations on *iso*-asparagine are scarcely relevant. It is true that in the ring form *iso*-asparagine and asparagine would not be distinguishable; but the position of the amino group may greatly affect the relative stability of the respective open-chain forms compared with the supposed ring. Since *iso*-asparagine seems to react blue with ninhydrin under the conditions in which asparagine reacts brown, it would seem to resemble glutamine more than asparagine in this respect.

With respect to the contrasted behaviour of asparagine and glutamine to nitrous acid, the definitive thing is that in the one compound (glutamine) both nitrogen groups react, whereas in the other (asparagine) only the amino group reacts. Leach and Lindley have in no way explained this difference. It still seems reasonable to us that, if the ring form exists, the equilibrium might be far in this direction and, this being so, and in the absence of special evidence to the contrary, this could be consistent with the virtual failure of nitrous acid to react with the amide group.

Leach and Lindley re-discuss the decomposition of the amides, asparagine and glutamine. They treat this as though hydrolysis alone were involved. It is, however, evident that on one hand (asparagine), hydrolysis and, on the other (glutamine), cyclization by loss of ammonia may be involved. This complicates comparisons with other amides. When the glutamine is substituted in the amide group, this precludes cyclization by loss of ammonia, and therefore the decomposition of such compounds by acid should resemble that of asparagine more than that of free glutamine. While we again recognize that this problem is a difficult one to resolve conclusively, we also believe that the arguments of Leach and Lindley have not yet led to finality.

The evidence of infra-red absorption spectra, as it was available to us through Dr. Gore, seemed to indicate a difference of structure between crystalline glutamine and asparagine. It is this evidence which Davies and Evans[4] now call in question from their re-examination; but they make significant reference to the fact that the spectrum of crystalline asparagine is somewhat variable from sample to sample in certain of the critical regions. A re-examination of an anhydrous specimen of asparagine, as carried out for us by Dr. Gore, still indicates a difference in absorption between asparagine and glutamine in the general region of 1,420 cm.$^{-1}$. We now recognize that the absorption of asparagine at 1,530 cm.$^{-1}$, which is still evident, should not be described as 'strong' (ref. 1), though it is not present in glutamine and we believe is not due to water as Davies and Evans suggest.

However, the cumulative evidence to which we referred[1], together with the new evidence which we were able to derive by the use of the ninhydrin reagent as applied to asparagine containing carbon-14, still seems to us to be in favour of a ring configuration for free asparagine as it exists in solution.

Although all these papers are of interest, they are scarcely conclusive. As we said earlier, the determination of the structure of asparagine by X-ray methods could be unequivocal for crystalline asparagine, whereas a synthesis of amino succinimide would also be conclusive according as it proved to be, when hydrated, identical or different from asparagine.

*Note added in proof.* Evidence bearing on the properties of asparagine and glutamine also comes through the work of Meister[5] on their α-keto acid analogues. Asparagine yields two separable keto compounds (*A* and *B*). One of these (*B*) readily gives a 2-4 dinitrophenyl hydrazone, readily decarboxylates and has an ultra-violet spectrum similar to that of a β-keto acid (cf. oxaloacetic). The other (*A*) does not give a phenylhydrazone, lacks the ultra-violet absorption and decarboxylates with more difficulty: this compound may be either cyclic or a polymer. Glutamine may also yield two keto analogues, though only one (*A*) has been isolated (as its barium salt) free from the other (*B*). Compound *A* gives a phenyl hydrazone; the amide group is easily hydrolysed giving α-keto glutaric acid. Compound *B*, which is less stable, has not yet been isolated. The further outcome of this work will be awaited with considerable interest.

F. C. Steward
J. F. Thompson

Department of Botany,
Cornell University,
Ithaca, New York.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Incorporation of 8-Azaguanine into Nucleic Acid of Tobacco Mosaic Virus

THE guanine analogue, 5 amino-7-hydroxy-1-v-triazolo(*d*) pyrimidine (guanazolo; 8-azaguanine), delays or inhibits the development of infection in the case of several plant virus diseases[1]. The activity of the compound is reversed by adenine, guanine and probably hypoxanthine, but not by several other naturally occurring purines. On current views of the action of antimetabolites, these facts would suggest that 8-azaguanine acts by blocking an enzyme system involved in the utilization of guanine and perhaps adenine by the virus. There is, however, the possibility that 8-azaguanine is sufficiently like guanine to be incorporated into the virus nucleic acid, replacing some of the guanine, but different enough to make a virus particle containing it incapable of further multiplication. With tobacco mosaic virus in inoculated tobacco leaves, 8-azaguanine causes a delay in the production of virus (measured by infectivity, by particle counts using electron microscopy, or by yield of extractable virus[2]). The results described here show that 8-azaguanine is incorporated into the nucleic acid of tobacco mosaic virus.

Tobacco plants, inoculated with a highly infective preparation of a 'type' strain of tobacco mosaic virus, were sprayed twice weekly, on all leaves, with 0·01 *M* 8-azaguanine in 0·1 per cent sodium bicarbonate, commencing the day after inoculation. Batches of treated and untreated plants were harvested at various times between three and thirty days after inoculation. Preparations of tobacco mosaic virus were obtained by the usual ammonium sulphate precipitation procedure. The method for isolation of virus nucleic acid and the analytical procedures used were those of Markham and Smith[3]. The method of printing chromatograms by the fluorescence of the spots[4] has proved particularly useful, since 8-azaguanine fluoresces strongly under both acid and alkaline conditions, while guanine compounds fluoresce strongly under acid conditions only. In addition, with 8-azaguanine the fluorescence method is about ten times as sensitive as printing by absorption. About 0·3 μgm. of 8-azaguanine can be detected on No. 1 Whatman paper printing on Grade 1 bromide paper.

On analysis, the virus nucleic acid from treated plants was found to contain less guanine (by approximately 3·5 per cent) than that from untreated plants. This deficiency was accounted for entirely (within the limits of experimental error) by an increase in adenine (Table 1). In the *iso*propanol–hydrochloric acid solvent used, 8-azaguanine would run with and be estimated as adenine.

When acid-hydrolysed nucleic acid (*N* hydrochloric acid, 1 hr., 100° C.) was run on two-dimensional chromatograms (first solvent: *iso*propanol–hydrochloric acid; second solvent: *iso*propanol–ammonia) an additional small fluorescent spot was present behind adenine in the second solvent system in the hydrolysate from treated virus, in the position expected for 8-azaguanine. The fluorescent material isolated by this procedure had an electrophoretic mobility on filter paper in borate buffer at *p*H 9 corresponding to that of 8-azaguanine.

Table 1. MOLAR RATIOS OF BASES IN NUCLEIC ACID OF TOBACCO MOSAIC VIRUS FROM CONTROL AND 8-AZAGUANINE-TREATED PLANTS

| Base | Molar ratios (means of 7 determinations) | | Difference control-treated | Difference required for significance at 0·01 *P* |
|---|---|---|---|---|
| | Control | 8-Azaguanine treated | | |
| Guanine | 0·979 | 0·943 | − 0·036 | 0·024 |
| Adenine | 1·103 | 1·134 | + 0·031 | 0·031 |
| Cytosine | 0·817 | 0·815 | − 0·002 | 0·021 |
| Uracil | 1·101 | 1·110 | + 0·009 | 0·058 |

In attempting to isolate 8-azaguanylic acid from alkaline hydrolysates of nucleic acid, advantage was taken of the fact (determined by paper electrophoresis) that the *pK*'s of the hydroxyl and amino groups in the triazolopyrimidines are lower than those for the corresponding purines. In the case of 8-azaguanine, the *pK* of the hydroxyl group is about 3 *p*H units lower than that of guanine. When nucleic acid from virus from 8-azaguanine-treated plants was hydrolysed with 1 *N* sodium hydroxide (at room temperature for 24 hr.) and subjected to electrophoresis on filter paper in borate buffer at *p*H 9, a fluorescent band was found, running in a positive direction slightly ahead of uridylic acid, the fastest-moving of the naturally occurring nucleotides at this *p*H. This band, which was absent in control preparations, moved about 1·4 times as fast as 8-azaguanine—approximately the mobility to be expected for 8-azaguanylic acid. This procedure was used to isolate the fluorescent compound free from other absorbing material except traces of uridylic acid. This was removed by chromatography in *iso*propanol–ammonia. Table 2 gives the approximate $R_F$ values of the fluorescent material and other compounds in two solvent systems.

Table 2

| Compound | Approximate $R_F$ in: *Iso*propanol–ammonia | Ammonium sulphate–water | |
|---|---|---|---|
| Guanine | 0·33 | | 0·16 |
| Guanylic acid | 0·08 | *a* | 0·33 |
| | | *b* | 0·42 |
| 8-Azaguanine | 0·27 | | 0·17 |
| 8-Azaguanylic acid | 0·05 | *a* | 0·33 |
| | | *b* | 0·40 |

In the ammonium sulphate solvent, the fluorescent material divided into two spots running in the expected positions for 8-azaguanylic acids *a* and *b*. This is strong evidence for the production of 8-azaguanylic acid from polynucleotides through the cyclic phosphate[5a].

The fluorescent compound contains phosphorus and had a base/phosphorus ratio of 1·4/1·0 (on one determination on only 0·5 μgm. of phosphorus). From the above we conclude that the fluorescent compound in alkaline hydrolysates is 8-azaguanylic acid, and that therefore 8-azaguanine is incorporated into the nucleic acid of tobacco mosaic virus. In two previous claims for the incorporation of 8-azaguanine into nucleic acids[5], since the material was isolated only as 8-azaguanine, the possibility that it was present as a contamination in the nucleic acid preparations was not eliminated.

In view of the large errors in infectivity measurements, it may be very difficult to prove whether, in fact, 8-azaguanine incorporated into the nucleic acid renders a virus particle 'sterile'.

The incorporation of 8-azaguanine suggests more directly than did reversal experiments that at least some plant viruses can utilize free guanine for synthesis.

In young pea embryos, most of the 8-azaguanine absorbed is fairly rapidly deaminated to give 8-azaxanthine, a compound which is inactive against all plant viruses that have been tested. If this deamination occurs in leaves of more mature plants, then most of the 8-azaguanine is rendered inactive. It would be in accordance with much recent evidence[6] suggesting the primary role of nucleic acids in virus infectivity to assume that 8-azaguanine has its effect through being incorporated into the nucleic acid and thus rendering the particle 'sterile'. If these assumptions be correct, it may prove profitable to search for a compound that will not be subject to deamination and that will lead to an increased incorporation of 8-azaguanine into the virus nucleic acid. From work on the biosynthesis of the natural purines into ribonucleic acids in other systems[7], two compounds that may have these properties in some degree are 8-azaguanylic acid itself (particularly the *b*-isomer) and the triazole equivalent of 4-amino-5-imidazole carboxamide.

I wish to thank Mr. P. R. Fry for some of the tobacco mosaic virus preparations, and Dr. Roy Markham for much useful discussion. This work was carried out while I was on leave from the Plant Diseases Division, Auckland, New Zealand.

R. E. F. Matthews

Agricultural Research Council
Plant Virus Research Unit,
Molteno Institute,
Cambridge.
March 27.

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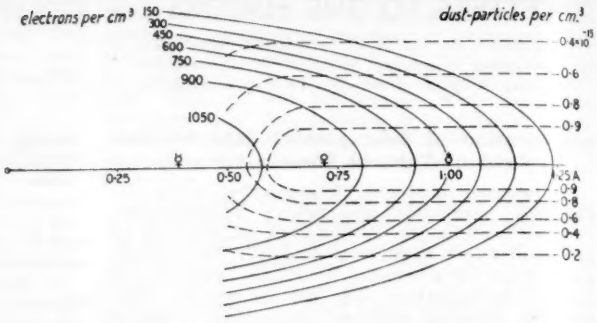
## Photoelectric Observations of the Zodiacal Light

It has been generally accepted that the zodiacal light comes from the scattering of solar light by dust-particles in the planetary system, which are concentrated towards the earth's orbital plane. On the other hand, it is known that the sun emits continuously a variable number of charged particles, principally protons and electrons. The possibility that the free electrons give some part of the luminosity of the zodiacal light has been discussed by F. L. Whipple aud J. L. Gossner[1], who derived maximum values of the possible electron densities in the space between sun and earth. For the following discussion of the density of electrons and dust particles in the planetary system we use the results of photoelectric registrations of brightness and polarization in the zodiacal light with a 1 *P* 21-multiplier. These were obtained during February/March and October 1952 and in the recent winter at the Hochalpine Forschungsstation Jungfraujoch (altitude 3,600 m.). Details of the apparatus and the observing and reduction methods are given in a paper by A. Behr and H. Siedentopf[2].




Lines of equal density for electrons and dust particles in the planetary system in a plane perpendicular to the ecliptic. Position of sun and inner planets marked by their symbols

The spatial densities of electrons and dust particles were derived from the observed values of brightness and polarization on the assumption that the polarized part arises only from the scattering by free electrons, whereas the dust-particles give no appreciable polarization. This supposition can be justified by the Mie theory of scattering by small particles. Since for dust particles with radii less than $10^{-4}$ cm. the radiation pressure of the sun is greater than the gravitational attraction, the main effect comes from particles with radii about $10^{-3}$ cm. (the number of particles per unit volume $n(r)$ decreases with radius $r$ nearly as $n(r) \sim r^{-3.5}$). For a mixture of particles with different radii it can be shown[3] that, for the angles of scattering encountered, there results no appreciable amount of polarization. Only if the particles are of oblong shape and if their axes are aligned, for example, by an interplanetary magnetic field, might a certain amount of polarization by the particles be possible. If this should be really the case, the number of electrons given in the accompanying diagram must be considered as an upper limit.

The diagram shows the mean distribution of electrons and dust particles as derived by solving numerically the integral equations connecting the brightness and polarization at the sphere with the density of electrons and particles in space. Whereas the observed polarization, and therefore the electron distribution, is symmetrical about the ecliptic, there is a distinct asymmetry in the distribution of brightness, also found by other observers. This asymmetry can be represented by a steeper decrease of particle numbers on the southern side of the ecliptic than on the northern side. We are not yet sure of the amount of this asymmetry, since the elimination of the ground brightness on the northern side of the evening zodiacal light is difficult because of the neighbourhood of the Milky Way and the increase of the air-glow towards the northern horizon. The numbers of dust particles given for the southern side of the ecliptic are therefore more reliable.

The resulting electron-density of about 600 per cm.$^{-3}$ near the earth's orbit gives a gas-density of about $10^{-21}$ gm.cm.$^{-3}$, since for electrostatic equilibrium one proton or other positive ion is necessary for each electron. The density of the dust—$10^{-15}$ particles cm.$^{-3}$—comes out to about $10^{-23}$ gm.cm.$^{-3}$ near the earth, or only a hundredth of the density of the gas. The decrease of density of dust towards the sun as shown in the diagram may be the result of evaporation of dust particles near the sun, as is similarly found in the nuclei of comets.

The brightness of the light-bridge connecting the morning and the evening zodiacal light is correctly represented by the above dust density (the contribution of the electrons to the light-bridge is small since their number decreases rapidly outwards). The luminosity near the counterpoint of the sun, the so-called counterglow (*Gegenschein*) with a diameter of about 20°, is 30 per cent higher than in the light-bridge. If the counterglow is explained as the result of a cloud of dust-particles near the outer libration-point in the system sun–earth[4], this cloud is situated at a distance of 0·01 astronomical units from the earth and has a density about thirty times higher than the mean density of dust near the earth's orbit.

H. Siedentopf
A. Behr
H. Elsässer

Hochalpine Forschungsstation Jungfraujoch.
March 12.

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## Action of Cortisone on the Polymerization of Actin

In adrenalectomized animals maintained on an adequate diet, the work capacity of skeletal muscle, as shown by the response to prolonged repetitive stimulation, is greatly diminished[1]. This effect is apparently not due to a direct failure of energy supply as could be expected from hypoglycæmia, but to an alteration in the metabolic or contractile system of the cell.

It has been shown by Horvath *et al.*[2] that the cardiac glycosides enhance the polymerization of actin prepared from cardiac muscle but do not affect actin from skeletal muscle. These observations have been confirmed in this laboratory, and the possibility that cortisone might act in a similar manner on skeletal muscle actin alone has been investigated.

Actin was prepared from skeletal muscle of the dog by the method of Straub *et al.*[3]. Solutions obtained by the extraction of 1 gm. of dry powdered muscle residue with 20 ml. of carbon dioxide-free distilled water had an actin content of 5–6 mgm./ml. Polymerization was followed by viscometry measurements at 10° C. using the Ostwald viscometer.

Our results show that cortisone in a concentration of 25 μgm./ml. added as a solution in propylene glycol increased the rate of polymerization twofold compared with a control preparation containing the solvent alone and of identical ionic constitution. This effect is apparent throughout the range of concentration of cortisone 0·25–50 μgm./ml. The polymerization was carried out at the physiological ratio of potassium to calcium (potassium, 0·054 *M*; calcium, 0·001 *M*) with a trace of magnesium (0·0005 *M*) and in the presence of veronal-acetate buffer of *p*H 7·4. All salts were present as chlorides.

Under identical conditions, actin prepared from the cardiac muscle of the dog showed no alteration in polymerization-rate when cortisone was present in a concentration of 25 μgm./ml.

The globular to fibrous transformation of actin effected by ions *in vitro* is an extreme case of small changes occurring in the actin particles in the intact cell and gives a good indication of these reactions. It would seem that steroid substances have a role in the regulation of contractile force through an influence on actin particles.

J. B. Cowle
R. H. Thorp

Department of Pharmacology,
University of Sydney,
New South Wales. Nov. 12.

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## Serum as a Source of Growth-factors for *Trichomonas fœtus*

Cailleau[1] concluded that cholesterol, ascorbic acid and a third unidentified factor were essential for growth of *Trichomonas fœtus*. Ascorbic acid, however, may only have been required because of its reducing properties[2]. The object of the present study was to investigate the nature of the factors in serum required by *T. fœtus* when grown in bacteria-free culture.

Stock cultures of the organisms were grown in 2 per cent glucose-broth over an inspissated serum slope, the medium being covered with a layer of liquid paraffin. Experimental cultures were grown in broth containing 2 per cent glucose and 7 per cent liquid horse serum. The inoculum gave an initial count of 200,000 organisms per ml. Without serum no significant multiplication took place; but when present in the medium a population of up to ten millions per ml. was obtained.

Preliminary investigations led to the preparation of a water-soluble extract of inspissated serum which would support growth when added to glucose broth. It was prepared by steaming together for 45 min. equal volumes of inspissated serum and distilled water. The final *p*H was 8. After steaming, the extract was cleared in a Seitz filter and then freeze-dried. The extract could be dialysed without loss of activity. When added to 2 per cent glucose-broth to give a concentration of approximately 0·15 per cent in terms of its protein content, optimum growth was obtained which could be serially subcultured. The extract contained a considerable amount of protein which could be precipitated by trichloracetic acid or by heating at *p*H 5.

The following analyses on a sample of the freeze-dried extract were kindly carried out by Dr. Winifred Watkins, who reported the material to contain total nitrogen, 10·5 per cent; total phosphorus, 0·6 per cent; inorganic phosphorus, 0·005 per cent; reduction and hexosamine (after hydrolysis for 8 hr. at 100° with 0·5 *N* hydrochloric acid), 4·6 per cent and 2·4 per cent respectively. The substance gave

a positive biuret and Liebermann–Burchard (cholesterol) reaction.

The method of preparation suggested that the extract might contain seromucoid, and the results of the analysis support this possibility. The total carbohydrate content is 4·6 per cent compared with a content of 10·7 per cent in seromucoid; but the ratio of hexose to hexosamine is approximately the same as that recorded for seromucoid[3]. The low carbohydrate value may be due to the amount of precipitable protein present.

The growth-promoting activity of the serum extract was not due solely to its cholesterol content, since by itself cholesterol would not support growth.

The essential components of serum for *T. fœtus* have thus been shown to be water-soluble, non-dialysable and stable to heating at *p*H 8. It is considered possible that one of the factors required may be seromucoid. The work is being continued, and it is hoped to elucidate further the nature of the growth-factors required by this organism.

J. K. Clausen

Lister Institute, London,
and
Institute of Animal Physiology,
Babraham, Cambridge.

Dec. 16.

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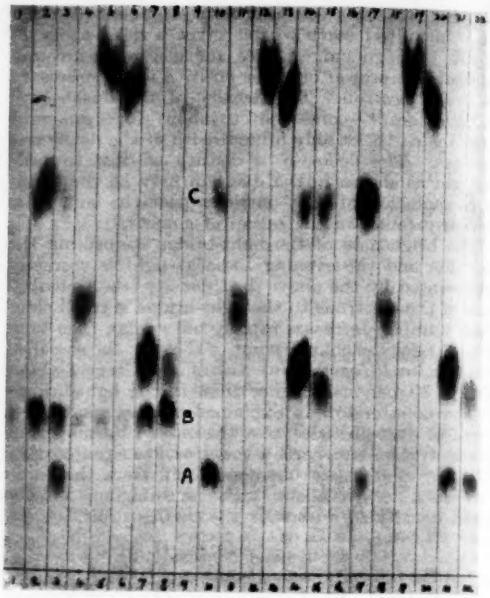
## A New Transamination Reaction

The isolation of γ-methylene-glutamine and γ-methylene-glutamic acid from groundnut plants has been described[1]. More recent studies, in which an attempt has been made to obtain information regarding the metabolism of the compounds, have indicated that transamination processes may be largely responsible for the breakdown of the γ-methylene-glutamic acid in groundnut plants.

The first experiments were of a qualitative nature only. Seeds germinated for four days at 25° in the dark were ground with half their fresh weight of *M*/5, *p*H 7·4, phosphate buffer solution and a little acid-washed sand until a smooth paste was obtained. The paste was squeezed through fine muslin and the filtrate centrifuged for 5 min. at 3,000 r.p.m. to remove finely divided debris. The supernatant was then enclosed in a collodion bag and dialysed against a stream of *M*/5, *p*H 7·4, phosphate buffer for 24 hr. at 3° in order to remove most of the free amino-acids found in the original extract. After dialysis the extract was used directly in the transamination experiments to be described.

The efficiency with which the α-amino-group of γ-methylene-glutamic acid was transaminated to three α-keto-acids (α-keto-glutaric, pyruvic and oxalacetic acids) was compared with that of certain other *l*-amino-acids previously found to participate in transamination systems in plant materials[2]. The reaction mixtures consisted of one volume of *M*/35 α-keto-acid solution (titrated to *p*H 7·4), one volume of *M*/35 *l*-amino-acid solution and two volumes of the extract. The amino-acids used were *l*-aspartic acid, *dl*-alanine, *l*-valine, *dl*-leucine, glycine and γ-methylene-glutamic acid (concluded to be the *l*-form from unpublished experiments). Synthetic γ-methyl-glutamic acid (presumably a *dl*-form) was also used. Transamination was allowed to proceed




Chromatogram prepared from 100 μl. amount of the following reaction mixtures. Nos. 1–8 contained 2 parts of extract, 1 part of *M*/35 α-keto-glutarate and 1 part of *M*/35 *l*-amino-acid as (1) water, (2) alanine, (3) aspartic acid, (4) glycine, (5) leucine, (6) valine, (7) γ-methyl-glutamic acid, (8) γ-methylene-glutamic acid. Nos. 9–15 contained 2 parts of extract, 1 part of *M*/35 pyruvate and 1 part of *M*/35 *l*-amino-acid as (9) water, (10) aspartic acid, (11) glycine, (12) leucine, (13) valine, (14) γ-methyl-glutamic acid, (15) γ-methylene-glutamic acid. Nos. 16–22 contained 2 parts of extract, 1 part of *M*/35 oxalacetate and 1 part of *M*/35 *l*-amino-acid as (16) water, (17) alanine, (18) glycine, (19) leucine, (20) valine, (21) γ-methyl-glutamic acid, (22) γ-methylene-glutamic acid. Spots found at level *A* are aspartic acid, at level *B* are glutamic acid, and at level *C* are alanine

for 4 hr. at 38°, and then the enzymes were inactivated by the addition of absolute alcohol to a final concentration of 70 per cent followed by warming. After the precipitated proteins had settled, aliquots of the supernatants from each reaction mixture were applied as spots to a chromatogram later developed in the usual manner for 24 hr. in phenol – ammonia. The relative amount of the products of the transaminations (glutamic acid, alanine and aspartic acid) can be estimated approximately from the sizes and intensities of the ninhydrin-developed spots on the chromatogram. The photograph of the chromatogram produced here shows that when α-keto-glutarate was used, the maximum and approximately equal amounts of glutamic acid were produced from γ-methylene-glutamic and γ-methyl-glutamic acids, alanine and aspartic acid. When pyruvate or oxalacetate was used, the maximum amounts of alanine or aspartic acid appeared to be produced when γ-methylene-glutamic and γ-methyl-glutamic acids were employed. The reactions between α-keto-glutarate and the three amino-acids, alanine, aspartic acid and natural γ-methylene-glutamic acid, when studied at intervals of 0·5 *p*H units between 5·0 and 8·5, all had *p*H optima of about 7.

The experiments in which α-keto-glutarate was used were repeated, the glutamic acid produced being determined quantitatively after separation from the other amino-acids on chromatograms developed for 40 hr. in phenol – ammonia[3]. Similar experiments were performed in which the seed extract was replaced by an equal volume of an extract prepared

| | Per cent of the α-keto-glutarate converted to glutamic acid | |
|---|---|---|
| | Leaf extract | Seed extract |
| Alanine | 10·4 | 38·9 |
| Aspartic acid | 17·2 | 37·7 |
| γ-Methylene-glutamic acid | 8·8 | 56·5 |
| γ-Methyl-glutamic acid | 9·1 | 55·5 |
| Leucine | 4·0 | 9·6 |
| Glycine | 0·8 | 2·2 |
| Valine | 1·4 | 2·0 |

The leaf extract contained 0·49 mgm. total nitrogen per ml.; the seed extract contained 7·9 mgm. total nitrogen per ml.

in the same manner from the leaves of 20-day old plants. The percentages of α-keto-glutarate converted to glutamic acid in the presence of various amino-acids are given in the accompanying table.

The larger amounts of glutamic acid formed in the presence of the seed extract are probably only an indication that it contains higher concentrations of enzymes than those present in the leaf extract. The total nitrogen contents of the extracts give support to this idea. The transaminase system responsible for the conversion of the naturally occurring γ-methylene-glutamic acid is presumably also acting on the non-natural γ-methyl-glutamic acid, and since the rates of transamination are not significantly different for the two compounds, the affinity of the enzyme for the two substrates would appear to be unaffected by the differences in the groupings on the γ-carbon atom.

Our thanks are due to Miss A. E. Wright for technical assistance during part of this work.

L. Fowden

Department of Botany,
University College, Gower Street,
London, W.C.1.

J. Done

Human Nutrition Research Unit,
Medical Research Council Laboratories,
Holly Hill, Hampstead,
London, N.W.3. Dec. 16.

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## Effect of Enforced Exercise on Myoglobin Concentration in Muscle

For many years it has been widely accepted that active muscles are generally redder than those which are little used. Such differences might be regarded as fortuitous, however, and unconnected with the state of activity. The red colour is principally due to the presence of the pigment myoglobin[1]. To secure a convincing indication that myoglobin is increased as a result of muscular activity, its concentration has been compared in the muscles of forcibly exercised and of inactive rats. In addition, the effects of enforced inactivity on myoglobin concentration has been studied in the pectoral and leg muscles of domestic fowls.

Myoglobin was estimated by a method previously described[2] and *p*H by the glass electrode.

The effects of short bouts of exercise of varying severity were first considered. Female albino rats six months old of uniform breeding were made to run on mechanically driven drums at 30 r.p.m., corresponding to a running speed of 120 ft./min. In Table 1 (*A* i, ii), values are given for myoglobin levels in the mixed hind-limb muscles after the rats had been exhausted by 1½ hr. of this treatment. To accentuate the shock arising under these conditions, the animals were starved for 24 hr. prior to being placed in the machine. It may be seen that the pigment concentration in the muscles of the exhausted rats was not significantly different from that in the control animals, which were in cages. Nevertheless, the treatment had greatly lowered the glycogen reserves of the muscles in the exhausted rats, as their ultimate *p*H was 7·24 ± 0·04, whereas that in the controls was 6·46 ± 0·02. (The ultimate *p*H derives from the conversion to lactic acid of all the glycogen remaining in the muscle at death[3].) When well-fed rats were subjected to moderate exercise, there was again no change in myoglobin-levels (Table 1, *B* i, ii and iii). It was once more evident, however, that the enforced exercise had affected the muscles, as the ultimate *p*H in the controls was 6·20 ± 0·03, and in the exercised rats 6·90 ± 0·21 (1½ hr.) and 6·94 ± 0·15 (3 hr.).

Table 1. Myoglobin in Relation to Enforced Exercise in Rats (mixed muscles of hind limbs)

| Group | No. of rats | Treatment | Myoglobin (% wet weight) | Sig. of diff. between means |
|---|---|---|---|---|
| *A* i | 6 | Unfed—exhausted | 0·094 ± 0·003 | nil |
| ii | 2 | Unfed—controls | 0·094 ± 0·009 | |
| *B* i | 3 | Fed—heavy exercise (1½ hr. 30 r.p.m.) | 0·097 ± 0·009 | nil |
| ii | 3 | Fed—heavy exercise (3 hr. 30 r.p.m.) | 0·105 ± 0·013 | |
| iii | 3 | Fed—controls | 0·096 ± 0·003 | |
| *C* i | 7 | Fed—trained (17 days, 2 hr./day) | 0·131 ± 0·006 | i > ii* |
| ii | 6 | Fed—controls | 0·104 ± 0·007 | |
| *D* i | 11 | Fed—trained (2 months, 2 hr./day) | 0·138 ± 0·006 | i > ii* |
| ii | 11 | Fed—controls | 0·111 ± 0·006 | ii > iii† |
| iii | 11 | Fed—'immobile' | 0·096 ± 0·006 | i > iii‡ |

* Significant at 5 per cent level. † Significant at 1 per cent level. ‡ Significant at 0·1 per cent level.

As a stress of short duration apparently produced no change in myoglobin concentration, the effect of moderate exercise every day over an extended period (17 days) was considered. Seven rats were exercised for 2 hr. a day at about 10 r.p.m. A similar number were retained as controls. In Table 1 (*C* i and ii), it may be seen that this procedure led to an increase in myoglobin-levels in the treated animals which was significant at the 5 per cent level. In the hope of accentuating this trend, a further batch of female albino rats six months old were subjected to treatment. One-third of their number were trained for two months, again for 2 hr. a day and at 10 r.p.m. (Table 1, *D* i): one-third were retained as controls (*D* ii); and the remaining third were kept 'immobile' in a confined space (*D* iii). It is readily seen that myoglobin concentrations in the trained group were higher than those in both the controls and the 'immobile' animals, the significance of the difference being high—at the 0·1 per cent level. Furthermore, the values for the controls were also higher than those in the 'immobile' group, although the significance of this difference was not so great (1 per cent level).

The ultimate *p*H values of the muscles from the trained group (6·07 ± 0·04) were significantly lower than those in the controls (6·18 ± 0·03) and in the 'immobile' animals (6·16 ± 0·05), suggesting a building-up of glycogen during training. Changes of *p*H of this magnitude have been reported before in

Table 2. Myoglobin in Relation to 9 Months Enforced Inactivity in Fowls

| Group | No. of fowls | Treatment | (% wet weight) Myoglobin gastrocnemius | (% wet weight) Pectoralis major |
|---|---|---|---|---|
| *A* | 10 | Normal activity | 0·177 ± 0·016 | 0·036 ± 0·001 |
| *B* | 10 | 'Immobile' | 0·116 ± 0·011 | 0·034 ± 0·001 |
| Significance of difference between means, at 0·1 per cent level | | | *A* > *B* | nil |

exercised rats, and the degree of acidity has been correlated with the quantity of lactic acid produced in the muscles[4].

The pectoral and leg (gastrocnemius) muscles of a group of fowls which had been allowed considerable freedom to forage, and of a comparable group closely confined in a battery over a period of nine months, were also analysed (Table 2).

Myoglobin concentrations in the gastrocnemius muscles of the normally active control group were significantly higher (0·1 per cent level) than those of the 'immobile' birds. It is interesting to note, however, that the pectoral muscles, which were not exercised by either group, showed no difference in pigment content.

It is concluded from these results that an increased myoglobin content represents one of the responses of muscle tissue to the influence of enforced activity, provided the latter continues over an extended period ('training'). Over a short period, even the most severe exercise elicits no such response, although it profoundly diminishes the glycogen reserves of the muscle.

I am indebted to Dr. D. G. Gilmour and Mr. R. W. Pomeroy, of the School of Agriculture, Cambridge, for making available the fowl muscles. The statistical analysis of the data in Tables 1 and 2 was carried out by the Statistical Laboratory, Mathematics Department, Cambridge. The interest shown in these experiments by Prof. D. Keilin and by Dr. E. C. Bate-Smith is gratefully acknowledged. The work described in this communication was carried out as part of the programme of the Food Investigation Organization, Department of Scientific and Industrial Research.

R. A. Lawrie

Low Temperature Station for
Research in Biochemistry and Biophysics,
University of Cambridge,
and
Department of Scientific and Industrial Research.

Dec. 22.

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## Hyaluronidase as an Adjuvant to Methylene Blue in staining of Nerve Fibres

It is notoriously difficult to produce consistent and uniform results in the vital staining of nerve fibres with methylene blue. Using Weddell's methods[1,2], both local and intravenous methylene blue in rabbits have given unsatisfactory results, with patchy and inconsistent staining.

Very considerable improvement in uniformity of staining of the nerve plexuses of the ear in rabbits has been achieved by adding hyaluronidase to the solution of the dye immediately before injection, in the proportion of 1,000 'Benger' units to 20 ml. of the dye solution. After local injection, diffusion of the dye throughout the corium and subcutis of the ear is rapid, particularly if the ear is lightly massaged. In other particulars, Weddell's method[1] has been followed.

Similarly, better staining is obtained after intravenous injection of methylene blue to which hyaluronidase has been added. Given intravenously, the enzyme appears to be relatively non-toxic; 6,000 units were added to the injection fluid in the case of a 2-kilo rabbit without apparent toxic effect. In all experiments the ordinary B.D.H. preparation of methylene blue was used as a 2·5 per cent solution in isotonic glucose. To prevent any possibility of saline over-dosage, the glucose solution has been used in preference to physiological saline as a vehicle for the dye. 20–30 ml. of the solution plus hyaluronidase were injected slowly over a period of 2–4 hr. The time factor is not significant. For examination of the nerve plexuses of the ear injection is made into one of the hind limb veins, as injection into the dorsal vein of the ear produces gross non-specific staining of the tissues around the site of injection from local diffusion of the dye.

Weddell[1] has pointed out the value of vasodilatation of the skin area being investigated, and certainly less uniform results in the ear are obtained when there is vasoconstriction. The induction of an acute inflammatory vascular reaction of the dorsal skin of the ear by rubbing with xylol during the injection period has produced the most consistent and uniform staining. This would suggest that uniformity of staining follows widespread capillary dilatation which reduces the need for tissue diffusion of the dye to the minimum.

The addition of hyaluronidase to the solution of methylene blue in supravital staining of nerve plexuses in human skin has also given promising results. An alternative to this method would be the injection of the enzyme locally into the skin before excision and supravital staining, since Bywaters *et al.*[3] have shown that the dermal barrier to the spread of dye after hyaluronidase injection is not reconstituted for 24 hr.

Ian A. McGregor

Department of Anatomy,
University of Glasgow. Jan. 6.

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## The *X*-Organ of Crustacea

Interest in the location and identity of the *X*-organ of decapod crustaceans has been renewed with the discovery of its neurosecretory nature, for it is one of the major sources for the secretory material of the sinus gland[1–3]. The total endocrine complex formed by these two organs strikingly resembles the brain – corpora cardiaca complex of insects. The appearance of the *X*-organ varies in different species; but apparent homologues have been located in the nervous system of the eye-stalk of decapods by either of two methods: (*a*) from the original observation of Hanström[4,5] that it is usually associated with the innervation of the sensory pore

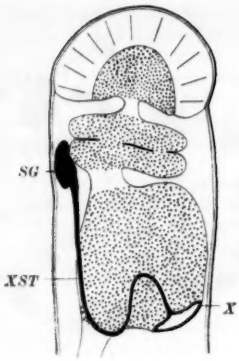


Fig. 1

or sensory papilla ; or (*b*) from the recent discovery[1–3] that the *X*-organ is linked to the sinus gland by the *X*-organ sinus gland tract, otherwise called the sinus gland nerve.

By examining a number of species of Crustacea (Stomatopoda : *Squilla mantis* ; Decapoda : Brachyura : *Carcinides* (= *Carcinus*) *mœnas*, *Pachygrapsus marmoratus*, *Maia squinado*, *Uca pugilator*, *Portunus corrugatus*, *Dromia vulgaris* ; Anomura : *Calocaris macandreæ* ; Natantia : *Crangon* (= *Crago*) *vulgaris*, *Lysmata seticaudata* ; Reptantia : *Palinurus vulgaris*) we have found that the *X*-organ in most forms contains at least three types of cell. In Brachyura, where the sensory pore is poorly developed or wanting, these different types of cells are commonly found together, usually at the proximal ventral corner of the medulla terminalis (Fig. 1) ; but in *Squilla* (Fig. 2) and in Natantia (Fig. 3) especially, the *X*-organ may be separated into two parts connected by a nerve.

In Brachyura, the most abundant cell type seems to be a big (30–40 $\mu$ diameter), pear-shaped, monopolar neuron, with a conspicuous nucleus and one to several nucleoli. The axon of this cell body is large, unbranched and leads to the sinus gland (Fig. 1). Secretory granules or droplets can be demonstrated by appropriate histological methods in both cell body and axon. These cell types are termed 'giant $\beta$ neurosecretory cells'[2] or simply '*X*-organ neurosecretory cells'[1,3].

The second, and less-abundant, cell type in the Brachyura is a spherical cell (*c.* 15 $\mu$ in diameter), the nucleus of which lies against the cell wall, while most of the perinuclear space is usually filled by a single inclusion which stains uniformly. Sometimes several smaller inclusions are present instead. No axon can be seen. A third, and least abundant, cell type consists of oval or irregular 'concretions of concentric structure'[5] lying adjacent to both the cells types already described. No clearly defined nucleus can be seen in these bodies, which may be products of secretion rather than cells.

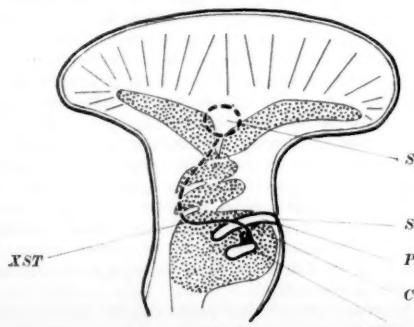


Fig. 2

In the Natantia examined, the two latter types of cell have been found close to the sensory pore. Cells of the second, spherical, type appear to be more numerous here than in the Brachyura, and they are characteristically ". . . shaped like a cluster of grapes surrounding the nerve from the medulla terminalis"[6]. These cells may form a syncytium. Cells of the first type (*X*-organ neurosecretory cells) are also present but are isolated from the other two kinds ; they occur in the medulla terminalis close to the point where the sensory pore nerve enters it. Fibres connect these two groups of cells.

In Natantia as well as Brachyura, the sinus gland is innervated by (and presumably receives secretory product from) the *X*-organ, but not from that portion of the *X*-organ close to the sensory pore. We propose that the two portions of the gland, where they are separated, should be termed *pars distalis X-organi* and *pars ganglionaris X-organi* (Figs. 2 and 3, *PDX* and *PGX*), while the nerve connecting them should be termed *connexio X-organi* (*CXO*), that is, *X*-organ connective.

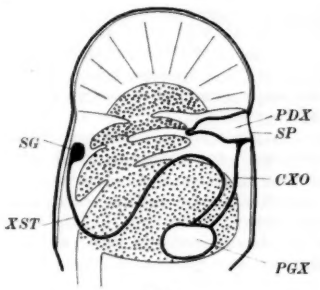


Fig. 3

*Dromia* and *Calocaris* show a degree of separation of these two portions of the *X*-organ intermediate between the extremes shown in crabs and shrimps.

We feel that these findings confirm the identification of the brachyuran *X*-organ by recent workers[1,3,6] and may explain why compatible results have not previously been obtained after *X*-organ extirpation in Natantia[7].

We wish to thank Dr. P. F. R. Dohrn for the *Calocaris* material placed at our disposal. One of us (D. B. C.) is aided by a grant from the Browne Fund of the Royal Society, and the other (L. M. P.) at present holds a National Science Foundation (U.S.A.) fellowship.

D. B. Carlisle

Marine Biological Laboratory,
Plymouth,
and Stazione Zoologica, Naples.

L. M. Passano

Osborn Zoological Laboratory,
Yale University. Dec. 17.

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[6] Bliss, D. E., and Welsh, J. H., *Biol. Bull. Woods Hole*, **103**, 157 (1952).
[7] Hanström, B., *Bull. Biol.*, supp., **32**, 98 (1948).

## Extension of the Salivary Chromosome Method to *Anopheles claviger*, *quadrimaculatus* and *aquasalis*

The cytogenetic method of investigation in malaria mosquitoes, based on morphological comparative study of salivary chromosomes, has been fruitful in the analysis of the *maculipennis* group. The results obtained are in good agreement with those of taxonomic studies based on egg morphology and larval chetotaxis; moreover, they permit systematic diagnosis also where such morphological differential characters vary too much or are altogether lacking. For example, where mixed *A. typicus* and *messeæ* occur in a larval breeding place, no larval character is sufficient for their discrimination, whereas cytological examination shows different structures in the *X*-chromosome which are absolutely constant and characteristic of each species. The method of examination is both easy and rapid.

Hitherto, only species of the *maculipennis* group have been thoroughly investigated in our laboratory by this method, although we could foresee a much wider field of application. Preliminary researches in *A. claviger* showed this species to be a suitable one for cytogenetic studies.

Last year we received from Dr. L. E. Rozeboom a strain, easy to rear in laboratory conditions, of *A. quadrimaculatus*; the species, which is widespread in North America—middle and eastern States—is considered to be one of the chief malaria vectors. Cytogenetic study of this species, based on the structure of the salivary gland chromosomes, also appears possible and promising.

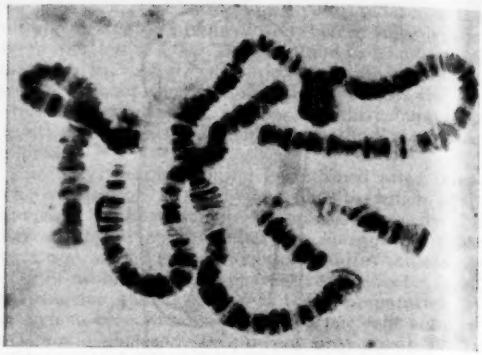
The mitotic chromosome picture consists of two mediocentric and one acrocentric, dot-like chromosomes, resembling those of *A. claviger* in somatic cells. Thus a preliminary investigation of the chromosomes of *quadrimaculatus* shows that the tip of one of them is similar to the end of the right arm of the third chromosome of the Italian *A. maculipennis*.

The end of the *X*-chromosome of *A. quadrimaculatus* also appears to be somewhat similar to that of *messeæ*.

Any hypothesis on phylogenetic relationship between palearctic and nearctic forms of the *maculipennis* group has little foundation at present; but this cytogenetic approach is the most promising one for such investigation. The banding pattern of *freeborni* and *aztecus* is almost identical with that of *atroparvus*; there are, however, rather extensive inverted regions.

According to Freeborn, *quadrimaculatus* is a member of the *maculipennis* group, filling up a niche, in the United States, and completing "the globe encircling holoarctic distribution of this variable and versatile species". My preliminary results support this point of view. It must be admitted that the chromosomic set of *quadrimaculatus* resembles more closely that of *claviger* than *maculipennis*, in ordinary mitotic or meiotic cells; but I think the difference between *maculipennis* and *quadrimaculatus* could be referred to the heterochromatic part. As a matter of fact, the *X*-chromosome in the salivary gland cells is almost the same in the two species, although it appears rather different in the mitotic set. The phylogenetic relationship between nearctic and palearctic species, however, is a problem requiring much further investigation and close co-operation between many research workers.

What is unquestionable is the possibility of extending to the American species of the *maculipennis* group the same method of investigation as that applied to the Italian species. Comparing *freeborni*, *aztecus* and *occidentalis*, differences can be found in the chromosomic structures which make differential diagnosis easier in larval breeding places (for example, between *freeborni* and *punctipennis* in regions where these species are co-breeders).



Salivary gland chromosomes of *A. aquasalis* (subgenus *Nyssorhynchus*)

The species mentioned belong to the subgenus *Anopheles*. We believe that the method can be applied fruitfully also to species of the subgenus *Nyssorhynchus*. Dr. Ivan Ricciardi, of the Malariological Institute of Rio de Janeiro, has recently come to this Institute, and brought with him eggs and larvæ of *aquasalis*. Both in larvæ collected in Nature and in larvæ reared in the laboratory, the structure of salivary chromosomes appears with a clarity quite comparable to that characteristic of the most suitable species of *Drosophila* and *Chironomus* (see photograph).

We hope that complexes like *tarsimaculatus* and others of the subgenus *Nyssorhynchus* will offer suitable material for the application of the cytogenetic method.

G. Frizzi

L. Spallanzani Institute of Zoology,
University, Pavia. Nov. 13.

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## Probable Relationship between the *Rhodometopa* Group of Cercariæ and the Trematode Genus *Renicola* Cohn

During the past year, a study of the trematodes of the genus *Renicola* from birds in British zoos has been carried out and certain interesting points concerning the genus have come to light.

Among other features to which particular attention was given is the excretory vesicle in a species which has been found on several occasions in the kidneys of various penguins. This species was first reported by Campbell and Sloane[1] from king penguins in the Edinburgh Zoo. The fact that they had found specimens in birds hatched in the menagerie, and certain other features of infections observed in London, seemed to indicate that this is not a normal parasite of penguins, but is more likely to be found in British sea-birds. With this in view, a search was started and, after several unsuccessful examinations, about ten specimens, similar to those from the penguins, were found in the kidneys of a common guillemot (*Uria aalge*).

An examination of the literature on larval trematodes from British marine gastropods showed almost

at once the very marked similarity between the excretory vesicle of young adults of this species of *Renicola* and that of the *Rhodometopa* group of cercariæ, particularly *C. pythionike* Rothschild[2]. In both cases the vesicle is *Y*-shaped with numerous lateral branches and with a connecting channel joining the two arms of the *Y* immediately behind the ventral sucker.

Evidence of this kind seems fairly strong, and further work is being carried out in the hope that a knowledge of the larval stages may help to establish more definitely the true systematic position of this somewhat disputed genus.

C. A. Wright

Department of Zoology,
Imperial College of Science and Technology,
London, S.W.7. Nov. 18.

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## Relationship between the Oxidative and Fermentative Phases during Adaptation to Galactose in *Saccharomyces cerevisiæ*

Aerobic adaptation to the utilization of galactose in *Saccharomyces cerevisiæ* occurs in two phases: an oxidative phase in which the respiratory quotient is 1, and a fermentative phase which follows it[1]. Further experiments have now demonstrated that during the oxidative phase of adaptation to galactose, the yeast cells are capable of fermenting galactose if anaerobic conditions are introduced. The degree of fermentation which resulted when anaerobic conditions were instituted was found to be correlated with the degree of adaptation during the oxidative phase as measured by the $Q_{CO_2}$.

These results confirmed previous ones which indicated that adaptation to the utilization of galactose is not concerned with oxidation or fermentation as such, but rather with an enzyme or series of enzymes which make galactose available to the cell for subsequent oxidation or fermentation[1]. Since the oxidative phase of aerobic adaptation was always followed by the onset of fermentation, provided the concentration of galactose was sufficiently high, it was of extreme interest to determine the factors involved in this shift from oxidation to fermentation under aerobic conditions.

It was found that, during the early stages of adaptation long before fermentation started, carbohydrate was being stored, some as glycogen and some as glycolytic intermediates, and pyruvate did not accumulate appreciably until storage of glycolytic intermediates was close to maximum. Therefore, it appears that storage occurs as soon as adaptation starts, and that only a relatively small amount of galactose is initially metabolized to pyruvic acid and oxidized through the tricarboxylic acid cycle. However, when storage is at a maximum and adaptation has proceeded sufficiently, galactose is metabolized at a greater rate to pyruvate until the oxidative mechanisms are apparently saturated, and pyruvate and acetaldehyde accumulate. It is at this point that fermentation starts. These conclusions are in agreement with previous results which demonstrated that, at low concentrations of galactose, adaptation occurred readily (as indicated by increase in $Q_{O_2}$, disappearance of galactose, and accumulation of glycogen) but that fermentation did not occur[1].

An important implication of these results is that fermentation is not a valid criterion for measuring the synthesis of the galactose-adaptive enzyme. The onset of galactose fermentation in yeast appears to be dependent upon the preliminary accumulation of reserves and intermediates, and only in a superficial way related to the kinetics of adaptive enzyme formation. Therefore, experiments using this method which purport to show that the synthesis of galactokinase is autocatalytic in nature are invalid[2], and theories which postulate the existence of extrachromosomal hereditary factors in order to explain the kinetics of galactokinase formation in yeast[2] are premature.

I wish to thank Dr. Carl C. Lindegren for encouragement during the progress of the work. This work has been supported by grants from the American Cancer Society, administered by the Committee of Growth, National Research Council, National Cancer Institute of the National Institutes of Health, Public Health Service and Anheuser-Busch, Inc.

A. Leonard Sheffner

Southern Illinois University,
Carbondale, Illinois.
Nov. 11.

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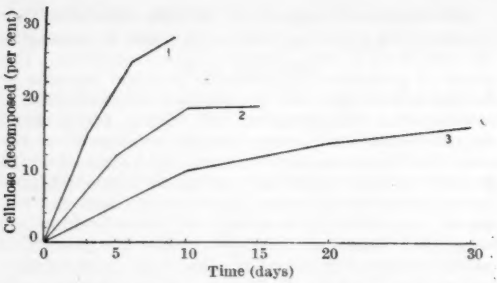
## Purification and Cellulolytic Activity of *Cellvibrio*

In recent years, several workers have paid a great deal of attention to the purification and the cellulolytic activity of aerobic cellulose-decomposing bacteria, especially *Cytophaga* and *Cellvibrio*. Isolations have generally been carried out by direct plating of soil suspensions on precipitated cellulose agar, and by enrichment cultures on silica-gel filter paper or on filter paper partly immersed in a liquid mineral medium. With the former method, most of the dishes are invaded by moulds and generally the formation of lytic zones is not very obvious.

In order to isolate *Cellvibrio*, a first enrichment was effected on silica-gel filter paper. After tenfold subculturing on the same medium, impurities in the form of other bacteria were still present. The impure strains were plated out on precipitated cellulose agar containing the common minerals, 0·1 per cent farmyard manure extract and 0·2 per cent cellulose. After seven days incubation at 26° C., different types of colonies were obtained. Some were surrounded by clear lytic zones while other colonies were not. All the *Cellvibrio* colonies that produced lytic zones on this medium showed a luxuriant growth when subcultured on filter paper agar. The strains obtained in this way were again plated on cellulose agar until only one type of colony with clear lytic zones was present. These strains were considered to be absolutely pure.

Not all strains of *Cellvibrio*, after enrichment on filter paper, produced lytic zones on precipitated cellulose agar to which farmyard manure extract was added. Some strains need other growth factors in addition to those present in the farmyard manure extract. More work will be done on the role of these factors in the formation of lytic zones by *Cellvibrio* on cellulose agar.

The pure cultures already have been maintained during four months by alternate subculturing on agar filter paper and precipitated cellulose agar provided with farmyard manure extract.




Vibrio 14: (1) pure strain on agar cellulose; (2) impure strain on agar cellulose; (3) impure strain on cellulose and mineral liquid medium

Impure strains, after many subcultures on silica-gel paper medium, and pure strains obtained by using the technique mentioned above, were tested for cellulolytic activity. We used two methods: growth in square-section bottles on a liquid mineral medium to which filter-paper strips were added, and a mineral agar medium covered with filter paper. Farmyard manure extract was not present in either media. The cellulose decomposition was measured by loss of dry-weight of the filter paper. The accompanying graph shows the results with an impure and a pure strain of *Cellvibrio* 14 on the two media.

It seems clear that the cellulose is more rapidly decomposed in the early stage of growth on the agar filter medium. The pure strain is also more active than the impure one.

Further results with other pure strains of *Cellvibrio* will be published elsewhere.

J. P. Voets
J. K. Van Hove

Laboratory of Microbiology,
State Agriculture University,
Ghent. Nov. 14.

## Some Factors affecting Heat Tolerance of Cattle and Buffaloes

Egyptian cattle, buffaloes and high-grade shorthorns were used for studying the effect of age, lactation and fattening on heat tolerance coefficients. The method developed by Rhoad[1] was used in estimating the heat tolerance, and the test was carried out twice during July 1952. The atmospheric temperature during test days ranged between 91° and 98·6° F., and relative humidity between 42 and 68 per cent. The average body temperatures of animals during March 1950 were taken as normal body temperature[2].

It was found that calves one year old had the lowest adaptability coefficient (see table). As young calves are sensitive organisms, probably their heat-regulating mechanisms are not as efficient as that of older animals.

Our results show that lactating animals are less tolerant than animals two years of age. It should be noted that mature animals used in this work were during their first month of lactation. Such animals consume more food than two-year old heifers and consequently their heat increment is increased; moreover, the endocrine and mammary glands of lactating animals are more active than non-lactating ones. These factors are responsible for increasing the body temperature of lactating animals and lead to a lower heat tolerance coefficient. The heat tolerance coefficients of non-lactating Egyptian cows, buffaloes and shorthorn grades have been found[3] to be 91·5, 75·7 and 89·2 per cent respectively; these are higher than those reported here for lactating animals and heifers two years of age.

Heat Tolerance Coefficients of Egyptian Cattle, Buffaloes and Shorthorn Grades at Different Ages

| Animals | Age | No. of animals | Heat tolerance coefficient | |
|---|---|---|---|---|
| | | | Rhoad's test | One reading |
| Egyptian cattle | Mature (lactating) | 4 | 80·4 | 80·3 |
| | 2 years | 8 | 84·1 | 83·5 |
| | 1 year | 8 | 78·5 | 77·9 |
| Buffaloes | Mature (lactating) | 10 | 69·5 | 66·0 |
| | 2 years | 9 | 71·8 | 67·7 |
| | 1 year | 10 | 64·1 | 59·2 |
| Shorthorn grades | Mature (lactating) | 9 | 72·0 | 71·0 |
| | 2 years | 8 | 74·8 | 73·5 |
| | 1 year | 10 | 62·0 | 61·2 |

To study the effect of fattening on the heat tolerance coefficient of buffalo calves, a group of three calves were given a rich ration of concentrates after weaning until they were eleven months of age. These calves gained about 1·5 lb. daily, while the control group gained only 0·7 lb. The average heat tolerance coefficient of the fattened group was 60 per cent compared with 64 per cent for the non-fattened ones. This difference may be attributed to the fact that fattened calves consumed three times as much food as that taken by the control animals, and consequently their heat increment should be greater than that of the controls. Deposition of more fat under the skin of fattened calves may be another factor in decreasing their heat tolerance.

The Iberia heat tolerance reported by Rhoad[1] requires that the body temperature of tested animals be recorded at 10.00 a.m. and 3.00 p.m. for three hot days (atmospheric temperature close to 90° F.). During the course of this experiment, body temperatures of animals were taken at 12.30 p.m., and heat tolerance coefficients were calculated using this reading only. It is interesting to note that the two estimates obtained are very close except in the case of buffaloes (see table). Work carried out in this department has shown that the body temperature of buffaloes increased with increasing the period of exposure to summer sun; whereas Egyptian cattle and graded shorthorns were not significantly affected[3]. This is probably the explanation of the discrepancy between the estimates obtained for buffaloes.

When individual heat-tolerance tests were calculated for each animal, it was found that there were significant differences between individuals of the same age. Some of the buffalo one-year old calves had to be removed during hot hours on test days. Highly tolerant animals should be selected for breeding, as such animals are more efficient in food utilization and production.

This work was carried out at the Animal Breeding Department, Faculty of Agriculture, Giza, Egypt.

A. A. Asker
M. T. Ragab
M. A. Ghany

Faculty of Agriculture,
Fouad I University,
Cairo.
Nov. 10.

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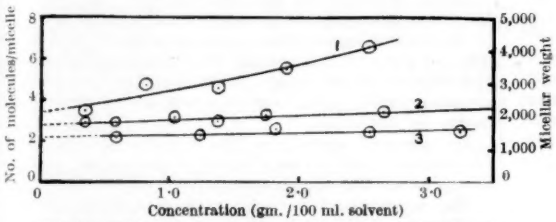
## Dipole Moments of Metal Oleates

Banerjee and Palit[1] have reported a value of 0·29 D. for the dipole moment of zinc oleate in contrast to values of 1·20 and 1·66 D. for the oleates of copper and magnesium. A possible reason for this anomaly has been found in the course of an ebullioscopic investigation of the micellar weights of some of the metal soaps in benzene and other solvents.

The dipole moments reported by Banerjee and Palit were evaluated by measuring the molar polarization of the oleates in benzene solution, using a heterodyne beat method. This procedure is based on the fundamental assumption that the solute is either molecularly dispersed or is approaching molecular dispersion in the concentration range in which the polarization measurements are made. Micellar weight data for zinc oleate, however, are shown in the accompanying graph.




Micellar weight and degree of association of zinc oleate in organic solvents: (1) benzene; (2) toluene; (3) *p*-xylene

These results demonstrate the presence, in all the solutions, of aggregates at concentrations well below those at which Banerjee and Palit made their polarization measurements. Further, the shape of the micellar weight-concentration curves provides no justification for the assumption that extrapolation of the polarization data to infinite dilution is likely to give a reliable value for the polarization of the molecularly dispersed solute. Aggregation was also detected ebullioscopically in solutions of the copper and magnesium compounds; but, in these cases, the accuracy obtainable did not warrant extrapolation of the micellar weight data to infinite dilution. The fact that aggregation occurs in all these solutions even at low concentrations suggests that the absolute values of the moments reported by Banerjee and Palit may be in error, although there is little reason to doubt that their measurements place the oleates in the correct order of polarity.

It should be noted that Banerjee and Palit's measurements were made at room temperature, whereas the micellar weight measurements now reported are at the boiling points at atmospheric pressure of the respective solvents. However, a comparison of the micellar weights of zinc oleate in benzene (boiling point 80·1° C.) and *p*-xylene (boiling point 138·4° C.) indicates clearly that, at room temperature in benzene, aggregates even larger than those observed at the boiling point are to be expected. The measured micellar weights are average values, and a high average micellar weight in solution does not therefore exclude the presence of some micelles of smaller size, or even of some molecularly dispersed solute. The measured polarizations are thus mean values for the different sizes of particles present in the solutions. Since the larger aggregates might reasonably be expected to be much less polar, the relatively high polarization values recorded by Banerjee and Palit provide evidence for the existence in the solutions of some particles considerably smaller than the average and possibly also for a small proportion of the monomeric solute. The ebullioscopic apparatus used in these experiments has been described elsewhere[2].

A. Gilmour
S. M. Nelson
R. C. Pink

Department of Chemistry,
Queen's University,
Belfast. Dec. 17.

[1] *J. Indian Chem. Soc.*, **27**, 385 (1950).
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## Optical Exaltation in Aromatic Compounds

It is known that the molecular refraction, as defined by Lorenz–Lorentz, of liquid (non-aromatic and non-conjugated) organic compounds may be calculated with fair accuracy by summation of the atomic refractions and the contributions to structural influences which may play a part (for example, olefinic double bonds). For aromatic compounds this additive character of the molecular refraction does not apply. Here the value measured is nearly always greater than the sum of the atomic refractions and contributions due to double bonds.

In determining the molecular refraction, the difficulty is encountered that, under normal conditions (20° C.), most of the aromatic compounds with three or more rings are solids, some of which have a very high melting point. This difficulty may be avoided by dissolving compounds the molecular refraction of which is required in a solvent with a known molecular refraction, determining the refractive index and the density of the solution, and afterwards calculating the molecular refraction of the solution from these results. The molecular refraction of the dissolved substances as a hypothetical liquid is denoted by:

$$R_{M_I} = \frac{R_{M_{I\,II}} - f_{II} \cdot R_{M_{II}}}{f_I}, \qquad (1)$$

where $R_{M_I}$ and $R_{M_{II}}$, $R_{M_{I\,II}}$ are molecular refractions of the dissolved substance, the solvent and the solution respectively; and $f_I$ and $f_{II}$ are molecular fractions of the dissolved substance and the solvent respectively. The molecular refractions of a number of aromatic compounds in the hypothetical liquid state at 20° C., calculated in this manner, are given in the accompanying table.

With the help of the values of the molecular refractions determined, we derived the corresponding refractometric exaltations (see table). Here the exaltation of an aromatic $C_pH_qO_rN_sS_t$ molecule is defined as:

$$E = R_M - (p.R_C + q.R_H + r.R_O + s.R_N + t.R_S), \qquad (2)$$

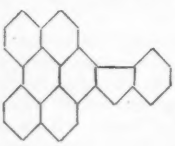
where $R_M$ is the measured molecular refraction of the compound; $R_C$, $R_H$, $R_O$, $R_N$ and $R_S$ are the atomic refractions of C, H, O, N and S, as derived from non-aromatic compounds. For the atomic refractions we used those which may be calculated from the bond refractions given by Vogel *et al.*[1]. $p$, $q$, $r$, $s$ and $t$ are the number of C, H, O, N and S atoms.

| Compound | Formula | $R_M$ | $E$ | $E/A$ |
|---|---|---|---|---|
| Acenaphthene | $C_{12}H_{10}$ | 52·0 | 10·6 | 1·06 |
| Fluorene | $C_{13}H_{10}$ | 54·7 | 10·7 | 0·89 |
| Acridine | $C_{13}H_{10}N$ | 63·8 | 18·4 | 1·31 |
| Anthracene | $C_{14}H_{10}$ | 65·6 | 18·9 | 1·35 |
| Phenanthrene | $C_{14}H_{10}$ | 62·2 | 15·5 | 1·10 |
| Pyrene | $C_{16}H_{10}$ | 72·5 | 20·7 | 1·29 |
| Fluoranthene | $C_{16}H_{10}$ | 71·5 | 19·7 | 1·23 |
| Brazan | $C_{16}H_{10}O$ | 75·8 | 22·3 | 1·31 |
| 2,3 Benzfluorene | $C_{17}H_{12}$ | 77·2 | 20·8 | 1·22 |
| Chrysene | $C_{18}H_{12}$ | 83·4 | 24·4 | 1·36 |
| 1,2 Benzanthracene | $C_{18}H_{12}$ | 82·6 | 23·6 | 1·31 |
| Hexahydroperylene | $C_{20}H_{26}$ | 90·0 | 17·6 | 1·26 |
| 1,2,5,6 Dibenz-anthracene | $C_{22}H_{14}$ | 104·9 | 33·5 | 1·52 |
| Coronene | $C_{24}H_{12}$ | 107·2 | 32·7 | 1·36 |
| Difluorenyl | $C_{26}H_{18}$ | 108·0 | 22·1 | 0·92 |
| $\beta$ Truxene | $C_{27}H_{18}$ | 114·9 | 26·4 | 1·10 |

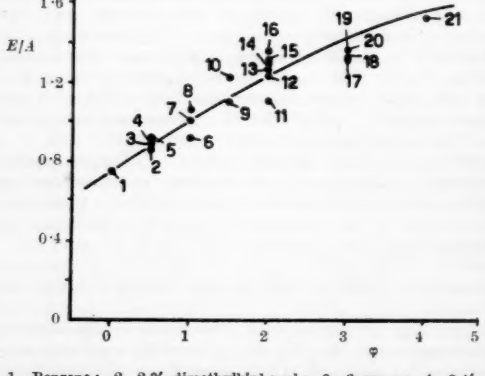
Now it appeared that the optical exaltation per aromatic atom ($E/A$) is far from constant, it being a function of a structure parameter $\Phi$, which we define as:

$$\Phi = r_{ar} - \frac{3}{2} i_{ar} + \tfrac{1}{2} j, \qquad (3)$$

where $r_{ar}$ is the number of aromatic joint bonds between aromatic 6-rings, $i_{ar}$ is the number of buried carbon atoms (completely enclosed by aromatic 6-rings), and $j$ is the number of direct covalent bonds between aromatic 6-rings (non-condensing). For example, the parameter $\Phi$ for the molecule



is given by $\Phi = 9 - \frac{3}{2} \cdot 4 + \frac{1}{2} \cdot 1 = 3{\cdot}5$ because $r_{ar} = 9$, $i_{ar} = 4$ and $j = 1$. The value of the structure parameter $\Phi$ is linked up with the geometrical asymmetry of the molecule. The correlation between the exaltation per aromatic atom $E/A$ and the structure parameter $\Phi$ is given in the accompanying graph. This correlation has been given a theoretical foundation.




1, Benzene; 2, 2,3′ dimethylbiphenyl; 3, fluorene; 4, 3,4′ dimethylbiphenyl; 5, 1 methyl 2 phenyl 4 *iso*propylbenzene; 6, difluorenyl; 7, naphthalene; 8, acenaphthene; 9, $\beta$ truxene; 10, 2,3 benzfluorene; 11, phenanthrene; 12, fluoranthene; 13, hexahydroperylene; 14, pyrene; 15, acridine; 16, anthracene; 17, 1,2 benzanthracene; 18, brazan; 19, chrysene; 20, coronene; 21, 1,2,5,6 dibenzanthracene

With the help of this correlation, it is possible to draw conclusions as to the structure of mineral fuels. Particulars about this correlation and about the method followed in the structural investigation will be published elsewhere.

D. W. van Krevelen
L. Blom
H. A. G. Chermin

Central Laboratory,
Staatsmijnen in Limburg,
Geleen.
Dec. 15.

[1] Vogel, A. I., Cresswell, W. T., Jeffery, G. H., and Leicester, J., *J. Chem. Soc.*, 514 (1952).

## A New Method of making Electron Microscope Specimen Support Films

It has been found that a thin film, suitable for specimen mounting, is formed over the mesh squares of an electron microscope specimen grid when dipped into a 1 per cent solution of 'Formvar' in chloroform, and allowed to dry in air. Very thin films, which are stronger than those wet-stripped from glass, can easily be obtained.

In each grid square, the film is uniformly thin over the central 70–80 per cent of the total area, thickening abruptly at the edges.

The accompanying photograph was taken by Mr. J. Dyson of this laboratory on an interferometer microscope[1] at a magnification of 500 diameters. The interference fringes can be regarded as contour lines of equal thickness. To make the photograph possible, it was necessary to cut across a grid in order to leave half the field free for the interfering beam. This required a thicker film than is usually made for the electron microscope; consequently, the uniform area is somewhat reduced. The loss in usable area is offset by the advantages that the films are easily and quickly made, entirely free from dirt and very rigid on the supporting grid.

A disadvantage arises when metal shadowing at small angles, because the vertical position of the film lies between the top and bottom of the grid bars; hence part of the area of each grid square is not shadowed. At angles of $\tan^{-1} \frac{1}{4}$ and $\tan^{-1} \frac{1}{3}$, shadowing generally covers the entire film.

Interference photograph of cut 'Formvar' film

To make the film, the specimen grid is held at the extreme edge in a fine-pointed pair of forceps, and immersed in the solution. On withdrawal, it is held horizontal and allowed to dry; this takes only a few seconds. The formation of the film is easily observed during drying, and best results are obtained when up to about one-third of the grid squares remain covered. If the whole grid is covered, the film is usually found to be too thick. To achieve this, two factors can be varied. The strength of solution can be between 0·5 and 1 per cent, and the amount of liquid remaining on the grid can be varied by the manner in which it is withdrawn from the solution. With practice, good thin films can be made without difficulty. It is important to remove the grid from the forceps immediately after the drying of the film is complete, otherwise any solution remaining on the forceps will form a thick blob of 'Formvar' on the grid which is liable to charge up electrically in the microscope. It is convenient to transfer the grid quickly to a second pair of forceps and remove any small drops of liquid which may remain at the point where it was previously gripped.

The method has been used over a period for routine work and has proved to be very satisfactory.

I wish to thank Dr. T. E. Allibone for permission to publish this note.

D. E. Bradley

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston Court,
Aldermaston, Berks.
March 30.

[1] Dyson, J., *Nature* [171, 743 (1953)].

## Frictional Electrification of Polar Polymers

It does not appear that any single mechanism suffices to explain frictional electrification completely[1,2]. The electrolytic mechanism of charge transfer has been discussed by Freundlich[3], but is generally taken to presuppose the existence of thin aqueous films on the surfaces, and to have only limited application to 'dry' solids[2]. Further, the conductance of even the thinnest of aqueous films is likely to suppress electrification on separation[4]. Nevertheless, electrolytic action accounts very satisfactorily for the behaviour of solids with polar properties. Thus Knoblauch[5] demonstrated the tendency of a large range of acids and bases to become electrified negatively and positively respectively, and obtained the best results with organic acids and bases. One concludes that the polar nature of these substances facilitated ionic processes in the presence of sorbed water molecules (not necessarily forming a separate phase), and that the acid donated excess positive ions (proton) and bases excess negative ions (hydroxyl). The results no doubt depend on the relative mobility of the ions, the larger ions tending to aggregate in both cases and were therefore less mobile than $H^+$ and $OH^-$ ions.

Excellent conditions for investigating electrolytic charge separation obtain with polar polymers, and in particular textiles and ion-exchange resins. The presence of the acid or basic groups promotes water sorption and consequent ionic dissociation and mobility even at low humidities[6]. One ion is, however, firmly bound to the polymer matrix and the other is free to take part in the charge transfer. For example, consider the strongly basic resin 'De-acidite *FF*', and the strongly acid 'Permutit' sulphonated polystyrene. We have:

$$R.NOH \rightarrow RN^+ + OH^-$$
$$R.SO_3H \rightarrow RSO_3^- + H^+,$$

with the respective positive and negative ions firmly bound; the resins donate freely diffusible $OH^-$ and $H^+$ ions respectively. This was indeed found to be true at about 30 per cent relative humidity, when the resins in powder form were shaken from a filter paper; the basic resin showed consistent positive charges and the acid resin negative charges.

Weak bases and acids were found to behave in a similar manner provided they were carefully neutralized (for example, 'Amberlite' *IR 4B* and 'Zeo-Karb' 216). It would seem that a similar mechanism also contributes largely to the electric charge acquired by wool keratin, which becomes positively electrified against filter paper; this is characteristic of polypeptides, which contain both basic and acidic groups against cellulose. Acidified horn keratin also becomes positively electrified against filter paper, while after treatment with dilute caustic soda it becomes negatively electrified. Similar reversals may be obtained with the resins, and in all these cases the direction of charge transfer is given by the sign of the boundary potential as deduced from the Donnan theory.

J. A. Medley

Wool Industries Research Association,
Torridon, Leeds 6.
Dec. 19.

[1] Shaw, P. E., and Leavey, E. W. L., *Proc. Roy. Soc.*, A, **138**, 502 (1932).
[2] Loeb, L. B., *Science*, **102**, 573 (1945).
[3] Freundlich, H., "Colloid and Capillary Chemistry" (Methuen, 1926).
[4] Medley, J. A., *Brit. J. Appl. Phys.* (in the press).
[5] Knoblauch, *Z. phys. Chem.*, **39**, 225 (1902).
[6] King, G., and Medley, J. A., *J. Coll. Sci.*, **4**, 1 (1949). Hearle, J. W. S., *J. Text. Inst.*, **43**, *P*194 (1952).

## A New Precision Method for the Measurement of Ultrasonic Velocities in Liquids

Several methods[1] are available for the determination of ultrasonic velocities in liquids, of which the liquid film method[2] offers many advantages. The new method presented here enables a rapid determination of ultrasonic velocities with a high degree of accuracy.

The experimental arrangement consists of the usual apparatus for observing the Debye–Sears diffraction pattern in liquids. A quartz *X*-cut wedge of 1–3 Mc./sec. range is mounted in the crystal holder with *X*-axis vertical and the tapered edge parallel to the direction of the light beam, and is excited by a Hartley shunt-fed oscillator. The ultrasonic waves generated by this wedge are communicated to the liquid contained in a glass cell mounted on a levelling stand. The levelling is then adjusted so that the bottom of the glass cell is truly parallel to the surface of the wedge in contact with the liquid. A stationary ultrasonic diffraction grating can now be set up in the liquid column only at those frequencies for which the liquid column is in resonance.

Intense diffraction patterns are observed at a large number of these frequencies, which are very closely spaced. Using a slow-motion gear on the oscillator condenser and a length of liquid column of 4 cm., the frequencies of a number of these diffraction maxima have been measured and found to be exactly

equally spaced, the frequency difference being in the range of 0·01–0·03 Mc./sec. for various liquids. The frequency difference $\Delta f$ between any two consecutive maxima is obtained by measuring the frequency interval for about a hundred maxima. The ultrasonic velocities are then evaluated by using the relation

$$V = \Delta f \times 2L,$$

where $L$ is the length of the liquid column and $V$ is the velocity of ultrasonic waves in the liquid. Results thus obtained for the velocities of ultrasonic waves in some liquids are shown in the accompanying table.

| Liquid | $L$ (cm.) | $\Delta f$ (Mc./sec.) | $V$ (m. per sec.) (26° C.) |
|---|---|---|---|
| Amyl alcohol | 3·3 | 0·0202 | 1,333 |
| Benzene | 4·0 | 0·0162 | 1,296 |
| Carbon tetrachloride | 3·9 | 0·0117 | 913 |
| Toluene | 3·7 | 0·0176 | 1,302 |
| Water | 5·0 | 0·0151 | 1,510 |

These values for the ultrasonic velocities are found to be in good agreement with those obtained by other methods. The accuracy of the results obtained is about 0·2 per cent. A higher accuracy of 0·02 per cent can be achieved with a precision wavemeter and thermostatic control of temperature of the liquid.

Though the method is simple, accurate and rapid, it is limited to transparent liquids and is not suitable for measurements at very high frequencies.

Further investigations are in progress. An interferometric modification of this method with a movable layer of mercury in the bottom of the ultrasonic cell as reflector is also under investigation.

B. Ramachandra Rao
K. Subba Rao

Physics Department,
Andhra University,
Waltair, India.
Dec. 8.

[1] *Phil. Mag.*, **5**, 1177 (1928); *Proc. U.S. Nat. Acad. Sci.*, **18**, 409 (1932); *Nature*, **133**, 176 (1934); *J. Chem. Phys.*, **14**, 608 (1946).
[2] *Nature*, **166**, 742 (1950).

## Structure of Magnesium–Lithium β-Phase Alloys

During no work magnesium–lithium–silver alloys, Hume-Rothery, Raynor and Butchers[1] examined X-ray powder photographs from binary magnesium–lithium alloys containing the body-centred cubic β-phase, or a mixture of this phase with the close-packed hexagonal magnesium-rich α-phase. Diffraction patterns from (α + β) alloys showed, in addition to fundamental reflexions, extra lines which were provisionally identified as derived from an $Fe_3Al$ type of superlattice in the β-structure. The extra lines persisted on annealing at temperatures up to 300° C. and were also present in diffraction patterns of thin rods quenched from 420° C., but were not observed in photographs from homogeneous β-alloys. It was suggested that the β-phase develops an $Fe_3Al$ type of superlattice very near to the (α + β)/β boundary. The existence of such a structure in a system of two components of such similar atomic size and electrochemical characteristics is surprising, but no further examination of the phenomenon was possible. More recently, however, the original diffraction patterns became available for re-examination; inconsistencies in the development of the suspected superlattice at various temperatures were noted, while identification of the extra lines with $Fe_3Al$-type ordering appeared uncertain. The appropriate region of the binary diagram has therefore been re-investigated.

| Alloy No. | Atomic % lithium | Annealing treatment | Phases present | Remarks |
|---|---|---|---|---|
| 1 | 34·0 | Quenched after 24 hr. at 400° C. + 24 hr. at 200° C. | β | Cast from under lithium chloride flux |
| 2 | 23·0 | 14 days at 420° C. followed by slow cooling to room temperature at 50 deg./day | α + β | Cast in argon, using the method of Hume-Rothery, Raynor and Butchers (ref. 1) |
| 3 | 32·7 | | α + β | |
| 4 | 22·1 | Quenched after 14 days at 400° C. + 21 days at 200° C. | α + β | Cast in argon with improved technique, using iron crucibles |
| 5 | 27·7 | | α + β | |
| 6 | 31·86 | | β | |
| 7 | 33·62 | | β | |
| 8a | 49·4 | Quenched after 48 hr. at 400° C. + 24 hr. at 300° C. | β | Cast from under lithium chloride flux |
| 8b | 49·4 | As for alloys 2 and 3 | β | |

The alloys used in the structural investigation are described in the accompanying table.

Exploratory experiments were carried out with alloy 1. The diffraction pattern, obtained in a 19-cm. powder camera with copper $K_\alpha$ radiation, showed a number of weak lines additional to the fundamental reflexions. The photograph could not be satisfactorily indexed in terms of an ordered structure of the $Fe_3Al$-type. Measurement of nineteen of the extra lines ($\theta = 8°$ to $\theta = 32°$) indicated, however, that they could be indexed on the basis of an ordered cubic structure of lattice spacing $a_0 \simeq 9{\cdot}7$ kX. Further reference to this is made below. Alloys 2 and 3 both gave rise to diffraction patterns containing extra lines which, however, did not correspond with those from alloy 1, and could not be indexed in terms of any simple structure, or with any simple ordered arrangement based on either the α- or β-phases.

From this lack of consistency it was suspected that the extra lines in alloys 2 and 3 might be associated with the presence of contaminants introduced during the preparation of the reactive alloys. The most likely cause of contamination is reaction of the molten metal with the atmosphere or with residual atmospheric impurities in the argon. A deliberately contaminated specimen was therefore obtained by heating a binary alloy in air until a considerable amount of reaction product (oxide and nitride) had accumulated. By comparison of this material, using monochromatized copper radiation in conjunction with a Geiger-counter spectrometer, with alloy 3 it was shown that the extra lines in the diffraction pattern of the latter from $\theta = 10°$ to $\theta = 35°$ corresponded exactly to the stronger lines in the pattern of the oxidized specimen. Further comparison showed that the extra lines on films obtained during the original work also corresponded with the stronger diffraction lines of the oxidized alloy. These experiments indicated that the apparent coincidence of the diffraction patterns in the original work with an $Fe_3Al$ type of structure was fortuitous, and that the extra lines were due to contamination.

To test this conclusion, alloys 4–7 were prepared under more stringently controlled conditions. Since the use of alumina crucibles leads to contamination

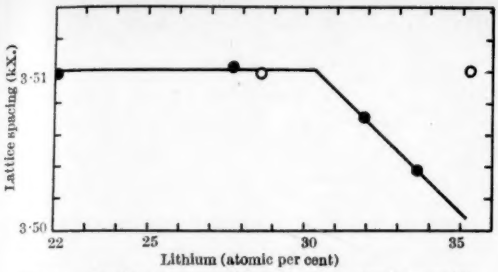



Fig. 1. ●—●—, iron crucible; O—O—, alumina crucible

by aluminium, the metals were melted in iron crucibles under argon which had been passed through a considerably enlarged purifying train to remove oxygen, nitrogen and water. Minimum preparation times were employed; the crucible was raised to the casting temperature before inserting the magnesium, and the lithium was added to the molten metal from a wire cradle without opening the apparatus. Casting also took place in the same enclosed apparatus, and the alloys were adequately protected from the atmosphere at all stages. The diffraction patterns showed only a few extra lines, of intensity considerably less than those observed for alloys 1–3. The few extra lines corresponded exactly with the strongest lines in the pattern of the oxidized specimen; their intensities did not vary with the amounts of α and β present. The striking reduction in the number and intensity of the extra lines by greater care in alloy preparation confirms that the effects arise from contamination, and not from superlattice formation.

Fig. 1 shows the lattice spacings (kX. at room temperature) obtained from the second series of alloys. For comparison, two measurements made on alloys prepared in alumina crucibles are included; one of these is clearly inconsistent with the results for alloys 4–7. The $(\alpha + \beta)/\beta$ boundary at 200° C. deduced from Fig. 1 lies at 30·3 atomic per cent lithium, which is not consistent with the extrapolation of the boundary reported at higher temperatures by Catterall[2].

As noted above, the diffraction pattern for alloy 1 indicated the presence of both the β-phase and a cubic structure of unit-cell side approximately 9·7 kX. The systematic absences and the relative line intensities may be accounted for by a structure with thirty-two atoms per unit cell as illustrated in Fig. 2. It is significant that the lattice spacing is nearly equal to $2\sqrt{2a}$, where $a$ is the lattice spacing of the body-centred cubic β-structure. In the basal plane (001) the atomic sites and distances are closely similar to those in the (001) plane of the β-structure; thus the new structure may be regarded as formed by an expansion of the [001] direction in the cubic structure by a factor of $\sqrt{2}$, accompanied by ordering.

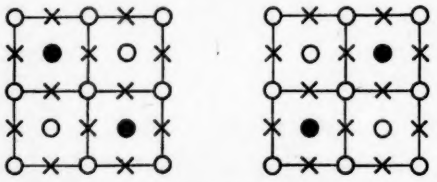


Fig. 2

○, Li } at heights 0 and $a$
●, Mg }
×, Mg at heights $a/4$ and $3a/4$

○, Li } at height $a/2$
●, Mg }
×, Mg at heights $a/4$ and $3a/4$

It is thus equivalent to a body-centred cubic arrangement, in which cube corners and two cube centres out of every eight are occupied by magnesium and the remaining sites by lithium, which has been stretched out vertically. This structure was not observed in the slowly cooled alloys 2 and 3, nor in the uncontaminated alloys 4–7, and is probably to be regarded as a transitional structure due to relatively short annealing times, and stabilized by impurities (oxygen and nitrogen).

It is of interest to note that alloy 8*a*, after comparably short annealing times, also showed a number of extra lines, which were almost completely absent from the diffraction pattern of alloy 8*b*. Such extra lines as were observed gave no indication of ordering near the equiatomic composition.

The new evidence available suggests strongly that no ordered structures exist at equilibrium in $(\alpha + \beta)$ alloys, or in alloys of composition in the range 30–34 atomic per cent of lithium, while no evidence for ordering at 50 atomic per cent lithium has been obtained.

R. L. P. Berry
G. V. Raynor

Department of Metallurgy,
University,
Birmingham 15.
Jan. 2.

[1] Hume-Rothery, W., Raynor, G. V., and Butchers, E., *J. Inst. Metals*, **71**, 589 (1945).
[2] Catterall, J. A., *Nature*, **169**, 336 (1952).

## Vesicular Laterite

Mr. G. Ap Griffith's contribution to the long-debated problem of the origin of vesicular laterite is welcome[1].

I am well acquainted with laterite beds and pavements in Ceylon and eastern and southern Africa, and I am aware of no case in which organic agency need be considered in the production of this very distinctive deposit. An up-to-date study of the subject is provided by Prescott and Pendleton[2].

More than forty years ago I watched Africans in the Mozambique Territory using laterite pellets, washed out of river banks by ephemeral streams, as shot for muzzle-loaders.

One might here record that both mature and semi-formed laterite can be found in certain places beneath the Kalahari sand in Bechuanaland. Stone implements may be found lying upon it, or otherwise associated with it, and examples of artefacts with fragments of the ironstone adhering to their worked surfaces are not wanting. The laterite so found is pre-Kalahari sand in age, and thus provides striking evidence of the pre-desert climate.

I have no doubt that Mr. Ap Griffith's solution of this laterite problem is correct, so far as it goes. Laterite pellets and nodules can be seen in process of formation to-day; but in many places optimum conditions for the production of vesicular laterite no longer obtain.

E. J. Wayland

The Athenæum,
Pall Mall,
London, S.W.1.

[1] *Nature*, **171**, 530 (1953).
[2] Prescott, J. A., and Pendleton, R. L., "Laterite and Lateritic Soils". Comm. Bureau Soil Sci. No. 47 (1952).

# FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

## Saturday, June 13

ASSOCIATION OF CLINICAL BIOCHEMISTS, SOUTHERN ENGLAND AND SOUTH WALES REGION (at the Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London, W.1), at 1.30 p.m.—Demonstrations and Papers.

## Wednesday, June 17

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Sir Charles Normand: "Monsoon Seasonal Forecasting" (Presidential Address).

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.2), at 5.30 p.m.—Prof. S. R. K. Glanville: Flinders Petrie Centenary Lecture.*

## Thursday, June 18

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Messrs. A. W. Hanson, H. Lipson and C. A. Taylor: "Application of the Principles of Physical Optics to Crystal Structure Determination"; Messrs. J. Dutton, S. C. Haydon, F. Llewellyn Jones and P. M. Davidson: "Photo-ionization and the Electrical Breakdown of Gases".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. E. S. Barnes: "Isolation Problems in the Geometry of Numbers".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Annual General Meeting.

## Friday, June 19

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—"The Accuracy of Wind Forecasts for Aviation".

## Saturday, June 20

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, The University, South Parks Road, Oxford), at 11 a.m.—Scientific Papers.

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# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ENTOMOLOGIST IN THE TSETSE FLY OPERATIONS BRANCH, Department of Agriculture—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (June 20).

LASDON FOUNDATION FELLOWSHIP IN ORGANIC CHEMISTRY—The President, University College, Dublin (June 20).

LECTURER IN INORGANIC or PHYSICAL CHEMISTRY, and a LECTURER IN CIVIL ENGINEERING—The Secretary, Queen's University, Belfast (June 20).

LECTURER IN MICROBIOLOGY (with special qualifications in microbiological chemistry or cell biochemistry, and have undertaken independent research in some branch of these subjects)—The Registrar, The University, Reading (June 20).

LECTURER IN PSYCHOLOGY—The Secretary, The University, Aberdeen (June 20).

SENIOR LECTURER IN MATHEMATICS—The Registrar, College of Technology, Birmingham 1 (June 20).

ASSISTANT LECTURER IN PHYSICS, and a LECTURER IN ELECTRICAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (June 22).

PHYSICIST (with honours degree in physics) for radio-isotope work in the University Department of Medical Physics—The Registrar, The University, Leeds 2 (June 22).

PSYCHOLOGISTS in the Admiralty, Air Ministry, Civil Service Commission, and Prison Commission—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 75/53 (June 25).

ASSISTANT (temporary) IN THE DEPARTMENT OF AGRICULTURE (Animal Husbandry)—The Registrar, University College, Aberystwyth (June 26).

HOSPITAL BIOCHEMIST (with degree in chemistry or A.R.I.C.), and a RESEARCH ASSISTANT (biological) (with degree in physiology or zoology)—The Professor of Chemical Pathology, Westminster Medical School, 17 Horseferry Road, London, S.W.1 (June 26).

ASSISTANT LECTURER IN THE DEPARTMENT OF AGRICULTURAL ECONOMICS—The Registrar, University College of Wales, Aberystwyth (June 27).

LECTURER or ASSISTANT LECTURER IN GEOGRAPHY at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 27).

PHYSICIST (with first- or second-class honours degree or equivalent in physics) IN THE METALLURGY DEPARTMENT, Royal Aircraft Establishment, Farnborough, for work on X-ray diffraction of solids and liquids—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.136/53A (June 27).

RESEARCH ASSISTANT IN THE DEPARTMENT OF BOTANY—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (June 27).

ASSISTANT EXPERIMENTAL OFFICERS IN THE ENTOMOLOGY AND WEED ECOLOGY SECTIONS, and a SCIENTIFIC OFFICER IN THE IRRIGATION SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (June 29).

LECTURER and an ASSISTANT LECTURER IN THE DEPARTMENT OF LEATHER INDUSTRIES—The Registrar, The University, Leeds (June 29).

ASSISTANT AGRICULTURAL ECONOMIST (with a degree in economics, agricultural economics or agriculture) in the Eastern Province of the Provincial Agricultural Economics Service—The Secretary, School of Agriculture, Downing Street, Cambridge (June 30).

ASSISTANT LECTURER IN ANIMAL PHYSIOLOGY—The Secretary and Registrar, The University, Southampton (June 30).

COLVILLE FELLOWSHIP IN THE DEPARTMENT OF CHEMISTRY—The Professor of Chemistry, Royal Technical College, George Street, Glasgow (June 30).

GRADUATE STUDENTS IN PHYSICS, CHEMISTRY OR ENGINEERING, for Research Scholarships (5) tenable at the Universities of Oxford, Cambridge, London, Birmingham and Glasgow—The Secretary, The Gas Council, 1 Grosvenor Place, London, S.W.1 (June 30).

LECTURER IN PHYSIOLOGY, and a DEMONSTRATOR IN PHYSIOLOGY—The Registrar, King's College, Newcastle-upon-Tyne (June 30).

NUFFIELD RESEARCH STUDENTSHIPS AND FELLOWSHIPS for experimental and theoretical research in nuclear and elementary particle physics—The Professor of Natural Philosophy, The University, Glasgow, W.2 (June 30).

SENIOR LECTURER or LECTURER IN PARASITOLOGY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 30).

LECTURER IN MINING—The Registrar, King's College, Newcastle-upon-Tyne (July 1).

LECTURER IN CHEMISTRY (with special qualifications in physical chemistry)—The Registrar, University College, Cathays Park, Cardiff (July 4).

MAY AND BAKER RESEARCH FELLOWSHIP, for research on plant growth-regulating substances—The Registrar, Wye College, Wye, Ashford, Kent (July 4).

ASSISTANT IN EXPERIMENTAL PHYSICS—The Secretary, The University, Aberdeen (July 8).

SENIOR EXPERIMENTAL OFFICER in the Ministry of Supply, London headquarters, for research and development of natural and synthetic aircraft textile materials in all forms, technical consultations with industry and research organizations concerning selection of materials, manufacturing and user problems, and the preparation of specifications—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4216/53 (July 8).

ASSISTANT IN STATISTICAL RESEARCH—The Secretary, Faculty Board of Economics and Politics, The Marshall Library, The University, Downing Street, Cambridge (July 15).

LECTURER or SENIOR LECTURER IN PHILOSOPHY at Canterbury University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

SENIOR RESEARCH AWARDS for investigations on the following aspects of locust physiology: (*a*) nutrition, with a view to developing a fully sufficient artificial diet, (*b*) vision and visual responses, (*c*) heat and/or water metabolism—The Director, Anti-Locust Research Centre, c/o British Museum (Natural History), Cromwell Road, London, S.W.7 (September 1).

PLANT PATHOLOGIST (with a wide knowledge of plant pathology in all its branches and, preferably, with tropical experience; and some aptitude for, and interest in, taxonomic work) in the Commonwealth Mycological Institute—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (September 15).

ASSISTANT (Grade A) IN PHYSICS—The Principal, Technical College, Queen Street South, Huddersfield.

ASSISTANT LECTURER IN AGRICULTURAL CHEMISTRY (with special qualifications in animal nutrition), and a DEMONSTRATOR IN AGRICULTURAL CHEMISTRY, in the Department of Agricultural Sciences, School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

BIOCHEMIST or CLINICAL BIOCHEMIST interested in human biology, to assist Dr. J. M. Tanner in investigation of metabolic and endocrinological differences in man, their genetical bases, and their development during childhood—Prof. H. Barcroft, Sherrington School of Physiology, St. Thomas's Hospital, London, S.E.1.

CHEMIST at a Ministry of Supply Research Establishment near Sevenoaks, for inorganic analysis—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.228/53A.

EDUCATIONAL PSYCHOLOGIST (woman)—The Director of Education, County Education Office, Castle Street, Worcester.

INVESTIGATOR (with degree in metallurgy, physics, or engineering, or equivalent qualification) IN THE DEPARTMENT OF INDUSTRIAL METALLURGY, for research on elastic properties of spring materials—The Registrar, The University, Birmingham 15.

METALLURGIST (with first- or second-class honours degree or equivalent in metallurgy, and at least three years postgraduate research experience) in the Ministry of Supply, London Headquarters—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.245/53A.

PRINCIPAL OF BHAVSINHJI POLYTECHNIC INSTITUTE, Bhavnagar (Bombay Region), India—The Ministry of Labour and National Service (A.S.12), Almack House, 26 King Street, London, S.W.1, quoting A.12/I.84E/53.

SCIENTIFIC ASSISTANT (with good knowledge of physics and radio maintenance) for service in the Antarctic with the Falkland Islands Dependencies Survey—The Crown Agents, 4 Millbank, London, S.W.1, quoting M3B/33763/TA.

SENIOR GENETICIST (with good honours degree in botany or other natural science, with some years experience of plant breeding and genetics) AT THE WEST AFRICAN INSTITUTE FOR OIL PALM RESEARCH—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.87/11/03.